Radio, Electronics and Communications

FORMERLY "RADIO & ELECTRICAL REVIEW" — WIDELY KNOWN SINCE 1946 AS "R. & E."

MPL

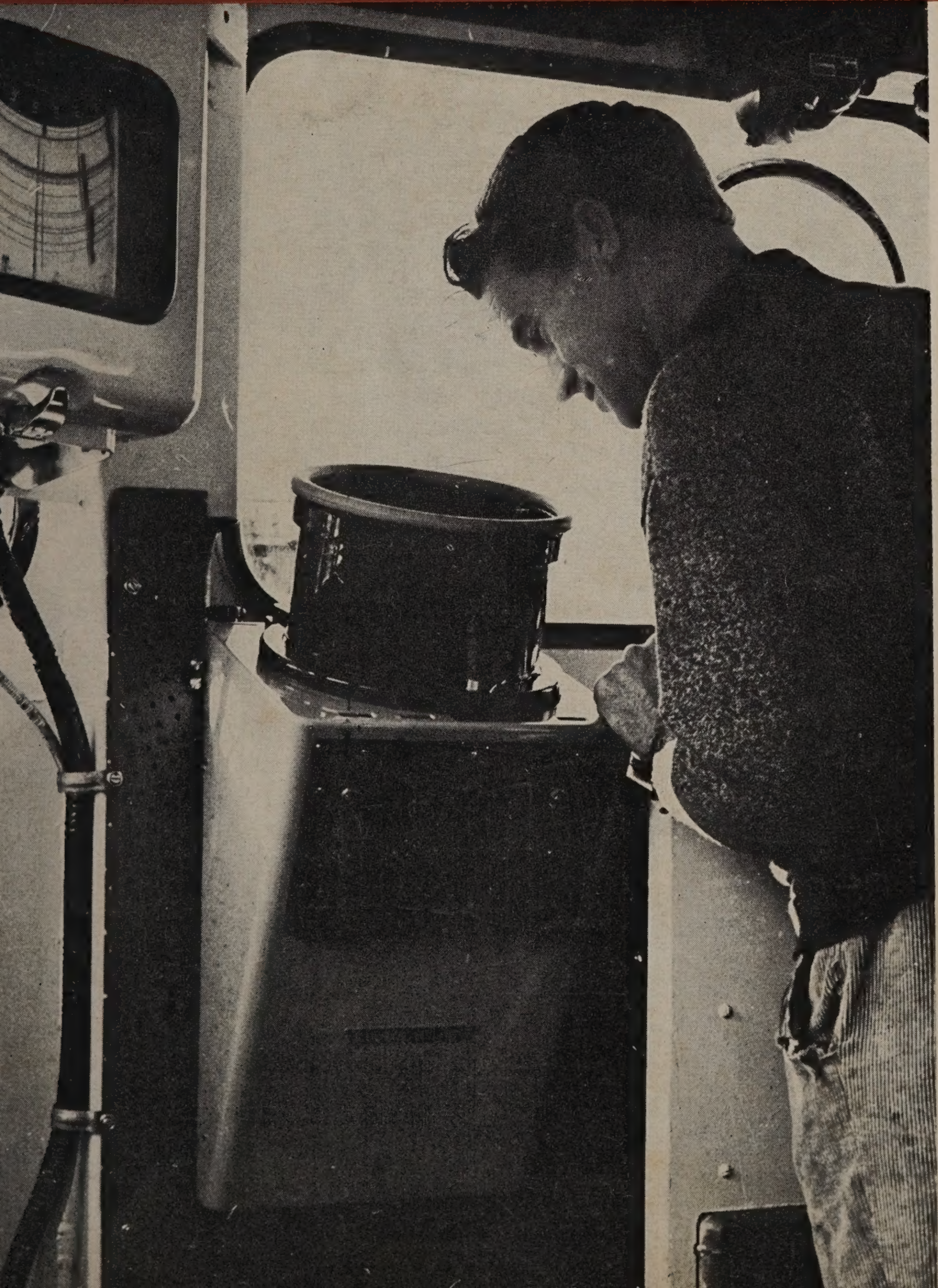
In This Issue . . .

- An introduction to voltage measurement — Part 2.
- Data transmission and the communication network.
- Performance characteristics of electronic counters.
- Circuit and Service data.
- Listening Post, New Products.

PUBLISHED MONTHLY IN THE INTERESTS OF THE N.Z. ELECTRONICS INDUSTRY FOR ALL LEVELS, FROM PROFESSIONAL TO AMATEUR.

VOLUME 21 NUMBER 9
NOVEMBER 1, 1966

PRICE **2/6**



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AWA

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to be replaced . . .

. . . there's one simple way for the service engineer to safeguard his good name. Replace with a Brimar valve. The same holds good for teletube replacements — the same dependability and trouble-free service that make for a really satisfied customer. No valves or teletubes are built to higher standards or are tested more thoroughly.

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ENQUIRY 424. USE FORM AT REAR.

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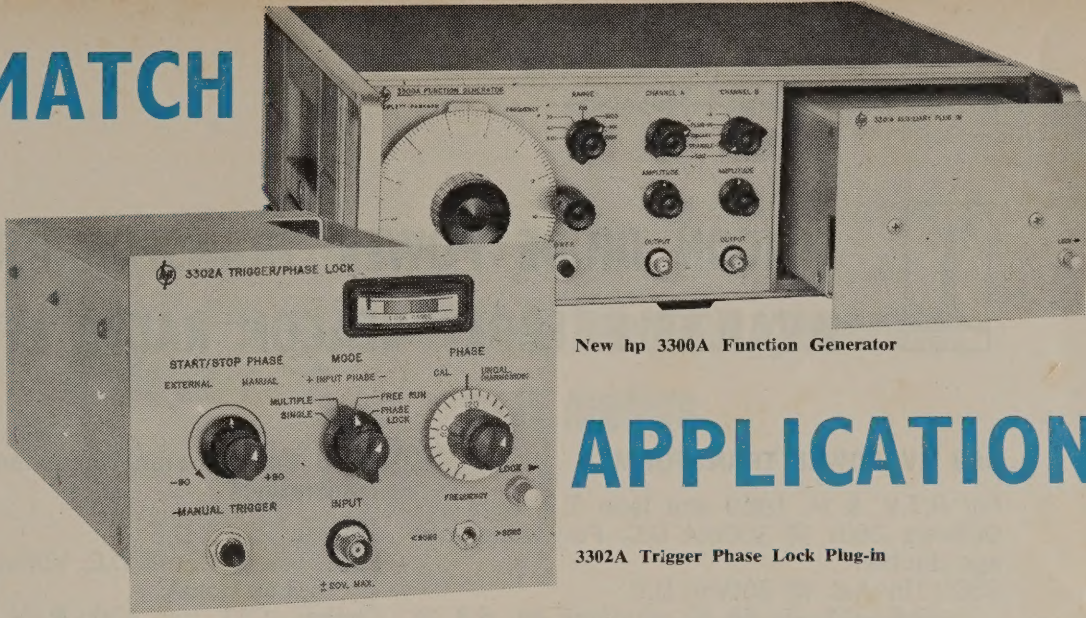


New hp 3300A Function Generator

3302A Trigger Phase Lock Plug-in

First Plug-in Function Generator to offer variable phase, phase-lock capability . . . plus these useful features:

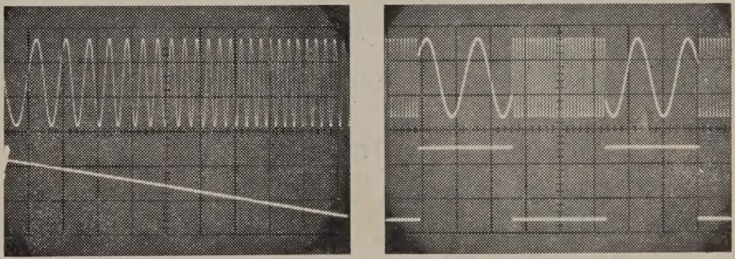
Accurate sine, square, triangular waveform output, amplitude controlled
Test signals 0.01 Hz (cps) to 100 kHz (kc), constant amplitude
Linear voltage programmability
Single-cycle, multi-cycle, free-run modes, with external trigger capability
Dual output amplifiers, uniquely isolated for maximum versatility
Sync pulse output for scope or recorder

Versatility finds a real definition in the new hp 3300A Function Generator, £306/7/6, with its 3301A Operational Plug-in, £10/15/0, and its 3302A Trigger/Phase Lock Plug-in, £102/2/6 . . . with more plug-ins to come!
All this for just £408/10/0.

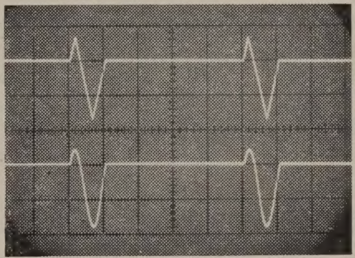
Any two of the three waveforms selectable by a front-panel switch, amplitude individually adjustable, over the entire frequency range. Frequency adjustable by front-panel dial (±1%) or by external voltage (+0.3 to 10 V will control frequency approximately 50:1). With the 3302A Plug-in, you also get single- and multiple-cycle operation with variable start/stop phase. Trigger input lets you phase lock onto fundamentals, harmonics, lock indicated by front-panel meter.

Output is dc coupled, fully floating, with an internal shield that reduces radiated interference and provides high CMR. Apply any dc offset voltage, up to ±250 V, using circuit, shield and power line rear-terminal grounds. You can use Channel B to invert the signal from Channel A, useful for driving balanced systems and other applications. 40 DB dynamic range, each amplifier, up to 35 V p-p into an open circuit, output impedance 600 ohms.

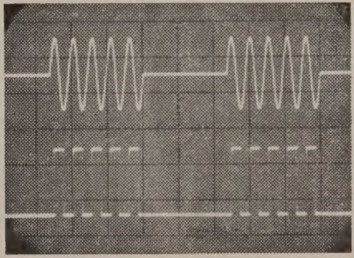
Here is an instrument that has to be seen to be appreciated: ideal for servo, medical, analog simulation, geophysical, subsonic and audio, vibration and frequency response applications. Explain your requirement to Sample Electronics. Or write for complete specifications. Prices shown are duty paid delivered anywhere in New Zealand.



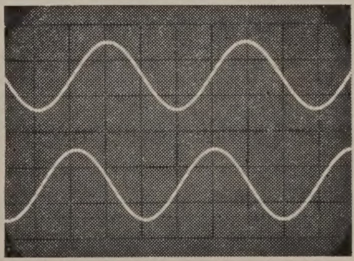
Voltage programming; frequency upper trace, programming voltage below.



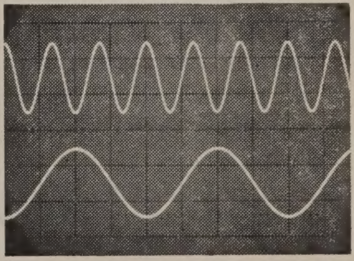
Single cycle—simultaneous triangular and sine outputs.



Multiple cycle—bursts of simultaneous sine and square-wave outputs.



Phase lock; output from function generator (upper trace) locked to external *fundamental* (lower trace).



Phase lock; output from function generator (upper trace) locked to external *harmonic* (lower trace).

S SAMPLE ELECTRONICS (N.Z.) LTD.
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SILICON DIODE POWER TRANSFORMERS AVAILABLE FROM BEACON RADIO LTD.

R98 T.V. POWER TRANSFORMER

For R.T.V. & H. 1959 and later T.V. Sets. Delivers 260v @ 300mA D.C. Full wave voltage doubler.
230:115v A.C. @ 300mA D.C.
:12.6v C.T. @ 5A (2 windings ea. 6.3 @ 5A).
:0—6.3—7.5—9 @ .6A. Picture tube winding.
Choke:—C36. Use 400v P.I.V. Diodes.

R103 Stereo Power Transformer

R.T.V. & H. Aug. 60. 7w Stereo.
230:245v @ 150mA. D.C.
:104v @ 150mA D.C. Voltage doubler Rect.
:6.3v C.T. @ 5A.
Choke:—C42. Use 400v P.I.V. Diodes.

R104 Stereo Power Transformer. 10w

320v @ 320mA. Voltage doubler Rect.
230:130v @ 320mA.
:6.3v @ 6A.
Choke:—C49. Use 500v P.I.V. Diodes.

R105 T.V. Power Transformer For Philips T.V. Kitsets

220v @ 420mA D.C. Voltage Doubler Rect.
230:106v @ 420mA D.C.
:6.3v @ 10A.
:0—6.3—7.5—9 Ov @ 0.3A. Picture tube Winding.
Choke:—C45. Use 400v P.I.V. Diodes.

R106 T.V. Power Transformer for Philips T.V. Kitsets

This type similar to R105 but less Picture Tube boost taps. Main Fils. 12.6v C.T. @ 5A.
220v @ 420mA D.C. Voltage Doubler Rect.
230:106v @ 420mA D.C.
:12.6v C.T. @ 5A (2 windings 6.30v @ 5A each).
:6.3v @ .3A Picture tube winding.
Choke:—C45. Use 400v P.I.V. Diodes.

R108 Small Stereo Headphone Power Transformer

250v @ 22mA D.C.
230:110v @ 22mA D.C. Voltage doubler Rect.
:6.3 @ 0.86A.
Choke:—C41. Use 400v P.I.V. Diodes.

R110 T.V. Power Transformer. For Philips T.V. Kitsets

This transformer uses full wave bridge rectifier. Requires no limiting resistor unlike equivalent voltage double types, also has advantage of no insulated capacitor and lower ripple output with smaller choke.
Output 220v @ 420mA D.C.
230:172v @ 420mA D.C. Full wave bridge Rect:
:12.6v C.T. @ 5A (2 only 6.3v winding @ 5A).
:6.3v @ .3A Picture tube winding.
Choke:—C50. Use 400v P.I.V. Diodes.

R111 T.V. Power Transformer

Similar to R110 but for R.C.A. type Kitsets.
260v @ 350mA from Rect.
230:207v @ 350mA D.C. Full wave bridge Rect.
:12.6v C.T. @ 5A (2 only 6.3v windings each 5A).
:6.3v @ 0.6A. Picture tube winding.
Choke:—C42. Use 400v P.I.V. Diodes.

R112 Oscilloscope Power Transformer

R.T.V. & H. 1963. Calibrated.
230:110v @ 80mA D.C. Full wave voltage doubler.
:6.3v @ 2.4A.
:6.3v @ 1A.
:6.3v @ 1A.
Use 400v P.I.V. Diodes.

BEACON RADIO LIMITED

Corner Brown and Fitzroy Sts., Ponsonby, Auckland. P.O. Box 2757. Telephone 12-168 (5 lines)

ENQUIRY 348. USE FORM AT REAR.

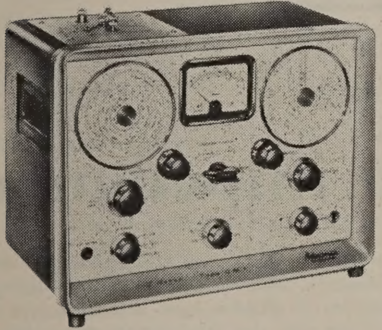
Advance

v.l.f. function generator & Q meters

SG88

V.L.F. Function Generator

Frequency range 0·005c/s to 50c/s for single cycle disc. Higher frequency is possible by use of 2, 3 or 4, etc., cycle disc. *Calibration* ±1% full scale. *Output* VOLTAGE Continuously variable from 200μV to 22V pk.pk. AMPLITUDE VARIATION Within 1dB over entire frequency range. IMPEDANCE At maximum output 6kΩ, mid setting 16kΩ, depending on frequency. WAVEFORMS Any single valued repetitive function. *Facilities* Direction of rotation of the waveform disc can be reversed, thus reversing the time sequence of the waveform. Automatic frequency sweep device on the 0·5 to 5c/s and 5 to 50c/s bands. Sweep time is approximately 2 minutes for any 10: 1 frequency excursion. Four waveform discs (sine, square, sawtooth and white noise) and one blank disc supplied. Special discs made to order. *Power requirements* 105 to 125V, 190 to 250V, 50 to 60c/s, 165W. *Dimensions* 19¾in (50cm) wide × 13in (33cm) high × 15in (38cm) deep. *Weight* 80lb (36kg).



CM1

'Q' Meter

'Q' range 15 to 600 in two bands. *Oscillator frequency* 100kc/s to 100Mc/s in six bands. *Frequency accuracy* ±1%. Stabilised signal level. *Main capacitors* Capacitor scales 10 to 70pF (±1pF), 40 to 600pF (±2%). Reactance (Xf) scales 16000 to 2200Ω–Mc/s; 4000 to 300Ω–Mc/s. Inductance (Lf^2) scales 2500 to 350μH–Mc/s²; 600 to 50μH–Mc/s². *Incremental capacitor* ±5pF (on 40 to 600pF range of main capacitor) in divisions of 0·2pF. *Accuracy of inductance measurement* ±(5% + residual inductance of 0·035μH). *'Q' range* 15 to 150, 60 to 600. *Accuracy* ±(5% + 5% F.S.D.) below 50Mc/s. For frequencies above 50Mc/s and 'Q' readings above 400 the tolerance should be doubled.

'% Q' scale Range ±10% (relative to nominal 'Q' reading). *Power requirements* 105 to 125V, 195 to 225V, 225 to 260V, 50c/s (models to suit other frequencies can be supplied). *Dimensions* 18in (46cm) wide × 14in (35·5cm) high × 9½in (24cm) deep. *Weight* 38lb (17kg).

T2

'Q' Meter

'Q' range 10 to 400 in two bands. *Accuracy* ±(5% + 5% F.S.D.) below 50Mc/s. *Oscillator frequency* 100kc/s to 100Mc/s in six bands. *Accuracy* ±1%. *Main capacitors* Capacitor scale 40 to 550pF (±2%). Reactance (Xf) scale 4000 to 300Ω–Mc/s (±2%) Inductance (Lf^2) scale 600 to 50μH–Mc/s² (±2%). *Incremental capacitor* 2·5pF. *Accuracy of inductance measurement* ±(5% + residual inductance of 0·03μH). *'% Q' scale* Range 10% (relative to normal 'Q' reading). *Accuracy* ±1% (i.e. ±1 division up to 50Mc/s). *Power requirements* *110 to 120V, 200 to 210V, 220 to 230V, 240 to 250V, 40 to 60c/s, 20W. *Dimensions* 15¼in (39cm) wide × 10¼in (26cm) high × 6½in (16·5cm) deep.

Weight 14lb (6·5kg).
**Special model available T2E 110 to 125V, 130 to 140V, 160V, 220V, 40 to 60c/s.*

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FROM THE COMPREHENSIVE RANGE OF Advance **INSTRUMENTS AND EQUIPMENT**

ENQUIRY 426. USE FORM AT REAR.

Now, sweep oscillators with interchangaeble RF Units!

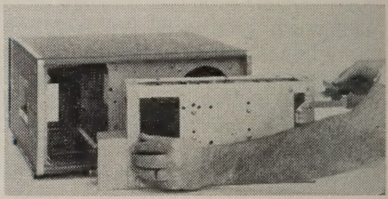
New Hewlett-Packard 8690-Series "Convertible" Sweep Oscillators provide all the convenience of "plug-in" construction while retaining the performance and operating features of conventional single-band units. A single main frame, Model **8690A**, accepts rf units for all frequency bands from 1 GHz to 40 GHz.

Two product design innovations contribute to the high performance of these new sweepers. First, the rf units or modules are inserted from the rear. Second, novel "snap-in" calibration dials may be interchanged in only a few seconds. Dials are full instrument width for high resolution, and are keyed, to eliminate the need for recalibration or adjustment when inserted.

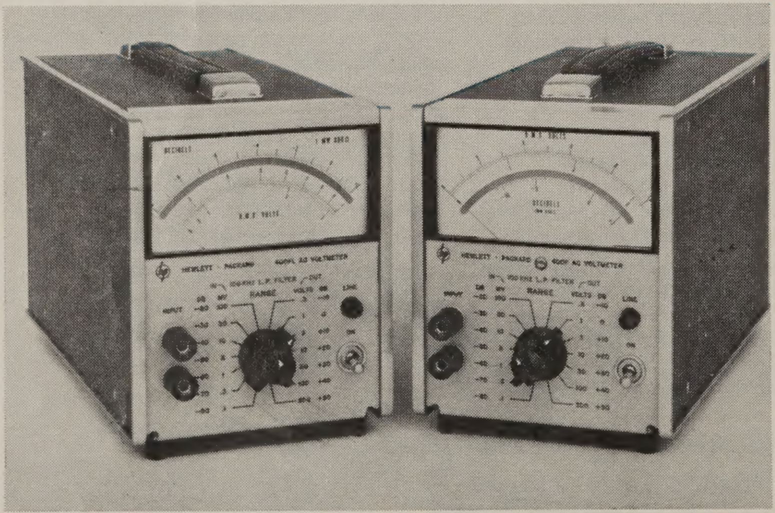
Three sweep functions, start-stop, marker sweep, and delta-F, are selected by pushbuttons. Manual or externally triggered sweeps may also be selected by front-panel controls.

The HP Model 8690A is priced at £852/10/-. The most commonly used rf units are priced as follows: 8691A (1 — 2 GHz), £1045. 8692A (2 — 4 GHz), £935, 8693A (4 — 8 GHz), £866/5/-, 8694A (B — 12.4 GHz), £866/5/-, 8695A (12.4 — 18 GHz), £935, 8696A (18 — 26.5 GHz), £1375, 8697A (26.5 — 40 GHz), £2365, PIN-modulated 8691B (1 — 2 GHz), £1210, 8692B (2 — 4 GHz), £1100, 8693B (4 — 8 GHz), £1045, and 8694B (8-12.4 GHz), £1058/15/-. Current delivery estimates on the 8690A and rf units are 12-14 weeks. Prices shown are duty paid, delivered anywhere in New Zealand.

Change scale when you change plug-ins



New h.p. AC Voltmeters higher sensitivity, high input impedance



The newest of the well-known Hewlett-Packard 400-Series AC Voltmeters, **400F** and **400 FL,** have 100 μv full-scale ranges, and 10 megohm input impedance. An ac output produces one volt rms for full-scale meter deflection, regardless of range and use; on the 100 microvolt range, the amplifier has 80 dB gain with less than 5 μv noise. Frequency range of the new instrument is 20 Hz to 4 MHz. Accuracy, in the range from 100 Hz to 1 MHz, is $\pm .5\%$ of full-scale $\pm .5\%$ of reading for the **400F,** and 1% of reading for the **400FL.** Model **400F** presents a linear voltage scale uppermost, while Model **400FL** presents a linear dB scale uppermost.

The extraordinary gain of the built-in amplifier, and the high sensitivity which is characteristic of the instrument, make it especially useful as a calibrated high-gain preamplifier for oscilloscopes, bridge detectors, and other devices. In accoustical measurements, sensitivity is sufficient that a calibrated microphone may be connected directly to the input terminals. Prices: Model 400F, £151/5/-. Model 400FL, £156/15/-. Duty paid. Delivery time—4 weeks.

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ENQUIRY 427. USE FORM AT REAR.

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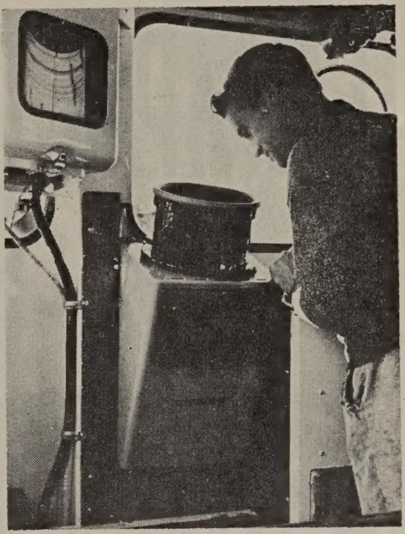
On Our Cover



ANOTHER FISHING VESSEL EQUIPPED WITH RADAR BY A.W.A.

Our front cover shows the modern New Zealand fisherman with radar display and recording echo sounder (top left) — both supplied and installed by Amalgamated Wireless (Australasia) N.Z. Limited.

The radar is the Kelvin Hughes Type 17 of which 35 installations are in service on New Zealand ships. This unprecedented standardization on one type of radar by New Zealand shipping companies and fishing fleets has brought tremendous advantages to their owners. Also, A.W.A. radar engineers have become so conversant with the set that installation can be completed very rapidly and service work, when necessary, can be done efficiently and quickly. Moreover, to assist with proper maintenance complete sub-units are available as spares at numerous A.W.A. service depots. This arrangement enables the defective unit to be replaced on the ship. The repairs are then done under ideal conditions in the service department ashore.

ENQUIRY 431. USE FORM AT REAR.

AWA

Coming . . .

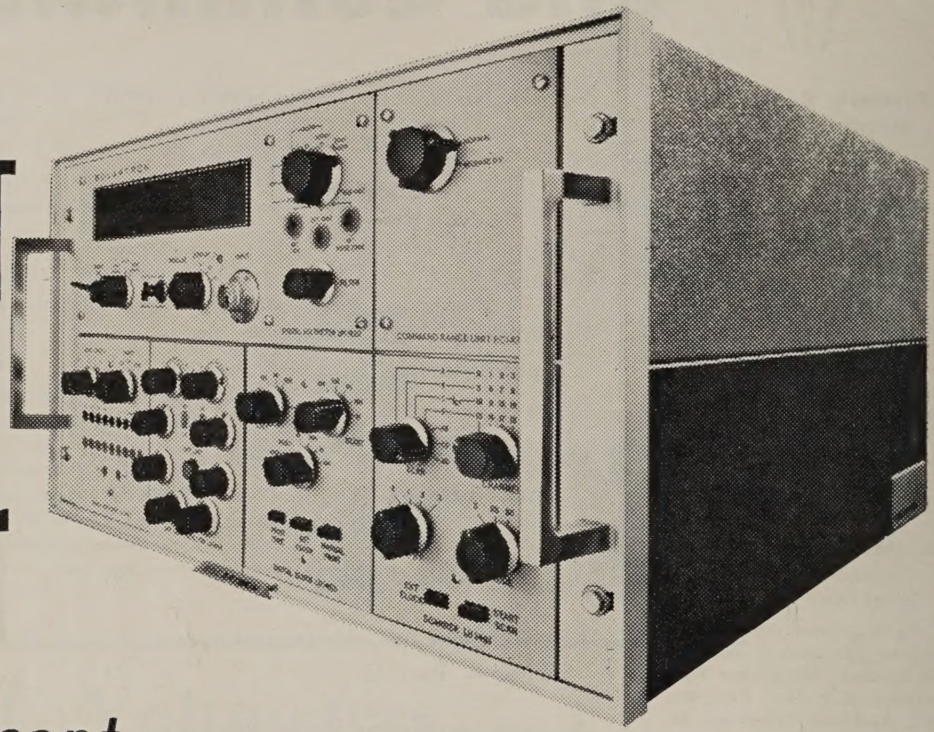
- Some aspects of system planning of earth stations.
- Physiological monitoring of patients following cardiac surgery.
- The technique of voltage measurements.
- A heavy duty guitar amplifier.
- FET's in audio pre-amplifiers.
- A miniature U.H.F. radiotelephone.

Also . . .

Book reviews
New products
Listening post
Circuit & service data

SOLARTRON

COMPACT Data Logger



a new concept in data recording

Takes DC voltages from thermocouples, strain gauges, transducers, etc., and records 20 outputs in printed form in less than seven seconds. This powerful monitoring system has been made possible by the introduction of the Solartron Integrating Digital Voltmeter. This low price high-performance voltmeter has high sensitivity and will reject unwanted signals in series and common mode. It is thus ideally suited to Data Recording applications. To match this outstanding instrument, Solarton have developed a comprehensive range of fully compatible data logging modules. These are assembled in standard cases, blank panels are supplied to replace any units not required, permitting expansion by easy stages.

- ★ **SENSITIVITY BETTER THAN 10μV.**
- ★ **ACCURACY 0.05%.**
- ★ **UP TO 120dB COMMON MODE REJECTION.**
- ★ **30dB SERIES MODE REJECTION.**
- ★ **CHOICE OF READ-OUTS.**
- ★ **AUTOMATIC RANGE SELECTION.**
- ★ **20 CHANNELS.**
- ★ **MODULAR CONCEPT FOR EXPANSION.**

SOLARTRON

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ENQUIRY 428. USE FORM AT REAR.

Letters from Readers

Sir,

"Mullard Automation Review" presents a new concept in industrial electronics by dealing with system design in modular form and thus in a language readily understood by electrical, mechanical and production engineers. Electronics, in this concept, is regarded simply as another production aid in the same way as hydraulics or pneumatics. This publication will demonstrate the application, rather than the detail, of electronic design, and subjects to be discussed in forthcoming issues are:

- Remote supervision and control
- Plant alarm systems
- Instrumentation
- Batch sorting and counting
- Variable speed drives
- and related subjects.

It is intended to distribute "Mullard Automation Review" quarterly, free of charge to senior personnel in industry, and copies may be obtained by applying on a company letterhead to the Publications Distribution Officer at Mullard Head Office in Sydney.

Readers may be interested in this new journal dealing with this important field. We draw the attention of interested readers to the last paragraph. —Ed.

Sir,

Would it be possible to supply me with the plans of printed circuit boards for the amplifier and preamp that appears in September, 1965 issue of your magazine, a stereo set up using R.C.A. silicon semiconductors.

If these plans are not available through you could you tell me where I could obtain them.

Ron Pilgrim,
Wellington.

We do not have available ourselves plans of the printed circuit board for the amplifier and preamplifier, however, an advertiser in the magazine — Kitronics — may well be able to help you and we have forwarded your enquiry to them. —Ed.

ENQUIRY 356. USE FORM AT REAR.

Proved best by test after test!

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NEW! NON-FLAMMABLE
TROL AID
CLEANER and LUBRICANT
for all Controls & Contacts
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CHEMTRONICS
NEW! NON-FLAMMABLE TUNER CLEANER
TUN O LUBE
CONTAINS TC-3, the miracle activated cleaner
DESIGNED FOR ALL TUNERS
TEE VEE RADIO LIMITED, AUCKLAND, WELLINGTON

TROL-AID

ACTIVATED CONTROL AND CONTACT CLEANER

TROL-AID cleans and lubricates controls, contacts, switches, relays and all other sliding contact devices . . . in one fast operation.

CHEMTRONICS' TROL-AID is a non-inflammable formulation of cleaners and lubricants . . . combined in an exclusive blend to provide longer-lasting protection against noise and oxidation.

STOPS T.V. AND RADIO NOISE

FREE Spray Extension for Pin-point Application.

8 oz. **17/6**

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ENQUIRY 363. USE FORM AT REAR.

1966

At this time of year we reflect on the previous months and try to take a peep into the future . . . It has been a difficult year one way or another, but for all that an interesting one. The first electronics conference has come and gone and was a well deserved success. We hope there will be another soon. Import licensing is still just as tough if no tougher than before and some items will be even more difficult to obtain than in the past. However it has always been our aim to serve you best and we hope that in a small measure we may have succeeded.

1967

To one and all who have helped us reach this time we like to say "thank you" and hope that the coming year will be a prosperous and fruitful one for all of us.

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ENQUIRY 423. USE FORM AT REAR.

A matter of Priority

by G. B. R. Feilden; F.R.S.

We reprint below an article from DESIGN*, the journal of the Council of Industrial Design, which we feel is particularly interesting in the context of the New Zealand economy. Although Britain is the subject of this article many of the problems and much of the advice is of equal importance to other, even much smaller countries.

The time is past when Britain can attempt to be 'all things to all men' in industry. So vast has the field of industrial activity become, that we must be more selective and concentrate on those developments for which we have particular advantages. Switzerland and the Scandinavian countries recognised this problem many years ago and have developed a range of specialised industries in which they have achieved and maintained leadership.

The recipe has been simple: the common factor has been the encouragement of industries with a large content of technology and of manufacturing skill, which has enabled the countries in question to rise above their geographical limitations. Their success has been based upon the high standard of education in their national institutes of technology. At these institutes, their designers have learned to adopt a fundamental approach to their work, which has been in sharp contrast to the rule of thumb methods which have all too often been used in Britain.

Who is to decide which industries shall be fostered in Britain and which allowed to decline and die? Evidently the ultimate decision must be dictated by economic factors, but these can be changed quite dramatically by the application of advances in technology. What we need, therefore, is an assessment of the growth potential of our existing industries, and of mechanisms for encouraging those which show promise. The Department of Economic Affairs, the Ministry of Technology and NEDC have been working on this problem and have collected statistics on where rapid growth may be stimulated. When the areas of growth have been identified, we must be prepared to back our judgement by spending money on encouraging the development of new projects based upon advanced technology. Not only does this mean making grants for the building and testing of new prototypes, but it will also be necessary to support courses in the specialised technologies applicable to the new products.

In the DSIR report on Engineering Design** we recommended the establishment of a number of advanced institutes dealing with specialised branches of technology, and this is an important element in the solution of our national problem. Though there has been a good deal of discussion on the subject, and some advanced design activities have been started (eg, at Cambridge, Liverpool and Glasgow universities) no institutes have yet been set up. The success of such institutes will depend upon finding individuals who have the enthusiasm and persistence to develop specialised schools in fields in which they are particularly experienced. Such schools have existed on the Continent for half a century or more, at the technical universities of Germany, Switzerland, Holland and elsewhere. Another area where radical re-thinking about our approach to design is needed in Britain, is the provision of support to smaller firms who cannot afford to maintain the fully-fledged design, research and development organisations which are recognised as necessary in larger companies. I believe that we have an opportunity to build upon the existing structure of co-operative research associations so as to include an advisory service on design which will enable our smaller companies to produce products which are in the forefront of technical development. Similarly, for industrial designers there is great scope for co-operation on a regional basis, allowing a number of local designers to divide their time between several small or medium sized companies in their area.

All observers agree that the quality of inventiveness in Britain is as active as ever. Where we have failed has been in applying invention. This is the field of engineering and industrial design, backed up by sound manufacturing and selling methods. What we must now do is to select the industries where we have advantages and do everything possible to encourage them to establish a world lead in their particular fields.

* Design Number 202, October 1965. p.25.

** Engineering Design HMSO

Performance characteristics of Electronic Counters

by A. F. Boff, B.Sc*

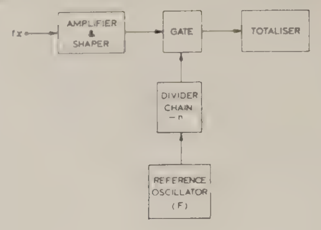

FIG 1. BASIC FREQUENCY COUNTER

The Electronic Counter itself needs no introduction. It is one of the most widely used measuring instruments and offers a standard of performance which is not matched by any other electronic tool for accuracy, resolution and convenience of use. Very early designs incorporated three or four digits and measured up to a few Kc/s. We have progressed to nine digit instruments measuring frequencies in hundred of Mc/s. What then are the limitations of this class of instrument. Can we go on indefinitely extending the frequency range, adding more digits, providing higher sensitivity? It is the purpose of this article to discuss practical considerations which limit the overall accuracy achievable with digital counting techniques. In the case of relatively low frequency instruments i.e. instruments counting up to a few hundred Kc/s, most of the problems to which the discussion refers, although present, are so small as to be insignificant. In counters designed for measurement of higher frequencies a correspondingly higher accuracy is usually demanded.

Some basic parts of a counter are illustrated in figure 1, and although there are many other circuit functions which are essential to the proper operation of a counter, these are not relevant to the points under discussion. The input signal is first passed through a shaper, generally combined with an amplifier to improve sensitivity, and is then offered to a gate. What the gate is open the pulses formed by the shaper pass into the totaliser causing binary circuits to operate and register the count. The gate itself is controlled from a reference frequency generally derived from a quartz crystal oscillator of varying specification according to the accuracy required. In all cases we are really measuring the ratio of two frequencies given by the expression:– $\frac{fx}{F/n}$. To simplify discussion, a 1 Mc/s crystal will be assumed and also a division ratio of 10^6 (=n). The gate is thus opened for periods of one second, a very common arrangement, and the display is direct reading in cycles per second. Accuracy of the indicated reading depends on a number of factors:–

(1) Accuracy of reference frequency (F)
(2) Stability of the divider chain
(3) Characteristics of the gate
(4) Digital ambiguity
(5) Characteristics of the amplifier/shaper circuits
(6) Waveform of the unknown frequency fx.

We will consider these individually.

(1) Accuracy of reference frequency (F).

Dramatic advances in techniques for generating accurate and stable frequencies have taken place in the last few years. The distinction between accuracy and stability is important in counter applications. For reasons of economy and portability it is essential to employ a quartz crystal as the internal reference. The inherent accuracy is therefore low and calibration against a more accurate source is necessary at intervals. Fortunately short term stability is high and in practice crystal accuracy need not be a limiting factor in measurements of, say, 1 part in 10^8. It is, however, necessary to recalibrate at intervals, and it is desirable to do this at regular intervals and to keep a record of corrections. In this way ageing characteristics will be established and corrections may be estimated between calibrations.

(2) Stability of the divider chain.

Before use, the reference frequency must be divided down in order to provide the desired gate time of one second. From a reference of 1 Mc/s this means a division by 10^6 which must be accomplished without introducing significant time variations. The avoidance of jitter requires considerable care in design. Binary division may be used provided that high speed circuits are used throughout, or alternatively pulse count down circuits of the integrating type may be used successfully. Non-digital frequency division may be employed in the high frequency stages but a very high signal to noise ratio must be maintained if phase jitter is to be avoided when conversion is made from sine-wave to pulse waveforms.

(3) Characteristics of the gate.

Ideally the gate should open and close instantaneously at one second intervals. In practice several nanoseconds are required for each open and close operation and it is necessary to consider the effect that this has on the measuring accuracy.

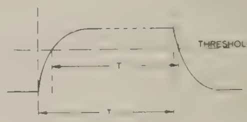

FIG. 2 GATE CONTROL WAVEFORM

Figure 2 shows the importance of equalising the effective rise and fall times of the gate waveform. Phase shift between control waveforms and actual gate operation is not important provided that the overall time interval is not changed. The 'threshold' is the level of the gate control waveform at which pulses supplied from the trigger circuit pass with sufficient amplitude to operate the totalizer circuits. T' is therefore the effective time during which the gate is open and should be made equal to T.

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*Racal Instruments Ltd.

(4) Digital ambiguity.

The ±1 count effect is well known and figure 3 illustrates two relevant cases. The pulse trains have slightly different repetition rates, and the gate is open for time 'T'. The optimum count is five for both pulse trains. Note that the error cannot be both +1 and −1 for a measurement of a fixed frequency. However if the input frequency is phase or frequency modulated a genuine ±1 count may apply. The digital ambiguity is a serious limitation in the measurement of relatively low frequencies. At a frequency of 100 Kc/s for instance this error amounts to 1 part in 10^5 in a measurement lasting one second and it is necessary to extend the measurement time if better accuracy or resolution is needed. Even at much higher frequencies the effect may be significant and at frequencies beyond the capability of digital logic circuits is often the reason for using a heterodyne conversion instead of a digital scaler or sub-harmonic transfer oscillator. A brief example will make this clear. If it is desired to measure a frequency in the region of 250 Mc/s and the maximum frequency response of the basic counter is limited to 100 Mc/s, we may retain a direct reading system if we use a decimal prescaler which will provide one output pulse for every 10 input pulses. Our basic counter will therefore indicate (in one second) 25 Mc/s ±1 cycle i.e. ±4 parts in 10^8. Use on the other hand of a heterodyne converter to carry out the same measurements would achieve, in the same gate time, an accuracy of ±1 cycle in 250 Mc/s, i.e. ±4 parts in 10^9. For both measurements, of course, errors in the reference frequency must be added to these figures.

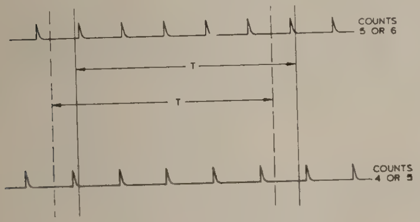

FIG. 3. DIGITAL AMBIGUITY

(5) Characteristics of the amplifier/shaper circuit.

It is a function of this circuit to supply to the gate a train of constant amplitude, constant shape pulses, one for each cycle of the input frequency (fx). It must therefore operate over an extremely wide range of input levels and frequencies and in many applications must accept wide variation in waveshape. The usual practice is to provide wideband amplification followed by a level-sensitive trigger circuit. The latter exhibits a finite hysteresis and the overall effect is illustrated in the waveform of figure 4. A pulse will be generated and passed to the gate whenever level AA' is exceeded following previous excursion beyond BB'. The maximum sensitivity of the counter is determined by the input required to overcome the hysteresis voltage represented by AA' to BB'. Clearly an input circuit which is driven by an adequate signal level, which amplifies without generation of harmonics and in which the trigger points are stable and noise-free will contribute no error to the measurement of frequency. Limitations do arise when these conditions are not met as discussed in the next section.

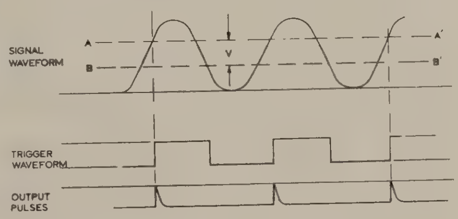

FIG. 4 TRIGGER CIRCUIT HYSTERESIS

(6) Waveform of the unknown frequency (fx)

So far discussion has been solely in terms of pure sinusoidal inputs of constant amplitude and frequency. In these cases it is necessary only to apply a signal of adequate amplitude to obtain answers correct within the limits set by the internal operation of the counter as discusssed in preceeding sections When waveforms are modulated or distorted, whether before or after entering the counter, there are additional factors to be considered.

(a) Amplitude Modulation

The performance of a counter when the input signal is varying in amplitude is easily evaluated by consideration of the input trigger characteristics. Clearly at minimum amplitude i.e. in the "trough" of the waveform envelope, the peak to peak amplitude must be sufficient to overcome the hysteresis voltage. Under these conditions it may appear that the counter is less sensitive in the trough than C.W. calibration would suggest. This is due to a shift in the mean trigger bias resulting from a d.c. component in the waveform or d.c. components generated by non-linearities in the input circuits. Temporary re-adjustment of the trigger bias control will correct this. However it is preferable to work with levels substantially above the minimum to reduce the risk of missed counts. A phase delay of up to $\pi/2$ occurs due to late triggering in the troughs but this is not important since the effect is absorbed into the digital ambiguity. As mentioned earlier this can contribute to a genuine ±1 variation.

(b) Pulse modulation

This is an extreme case of amplitude modulation and an application for which direct counting is not suitable. A transfer oscillator method must be used.

(c) Frequency Modulation

The frequency indicated by the counter is the average measured over the time that the gate is open. It follows, if the modulation frequency is not an exact multiple of 1 c.p.s., that the frequency indicated will not be the long-term average. The reading obtained may be higher or lower than the true value and successive readings will vary in accordance with the phase relationships between the gate and the modulated waveform. When appreciable frequency modulation is present it is important to ensure that bandwidth limitations are not exceeded for any part of the measuring cycle. This is particularly likely to arise if a stage of heterodyne conversion preceeds the digital counting. In these cases a high-frequency beat is preferable to a low frequency in order to avoid the possibility of modulation "through" zero.

(d) Pulse Train

Difficulties sometimes arise due to d.c. levels. Some commercial instruments provide direct coupling for all input circuits up to and including the trigger circuit. In addition an adjustable d.c. offset may be provided. Figure 5 gives a typical example. Note that unidirectional pulses having a small duty cycle provide a low d.c. level, even if the pulse amplitude is large. The negative component developed in AC coupling may not, without offset, be adequate to reset the trigger circuit.

FIG.5. USE OF OFFSET TO IMPROVE SENSITIVITY AND NOISE IMMUNITY

(e) Sinewave with interference

Consider that it is required to measure a frequency f_x of amplitude E_x in the presence of an interfering signal of frequency f_i and amplitude E_i. With regard to frequency we have three possible conditions:–

$$f_i < f_x$$
$$f_i = f_x$$
$$f_i > f_x$$

If f_i is less than f_x the composite waveform is similar to that produced in amplitude modulation and the effect can be assessed in the same way. Figure 6 illustrates the waveform. Neglecting d.c. effects we have as the limiting case $E_x - E_i = V/2$ where V is the peak-to-peak hysteresis voltage. Similarly when $f_i = f_x$ we may write by inspection $E_x - E_i = V/2$. When f_i is greater than f_x however a different and more sensitive situation arises because f_i may now cause inflection in the f_x waveform (figure7). The limiting condition in this case, obtained by differentiation of the composite waveform is:

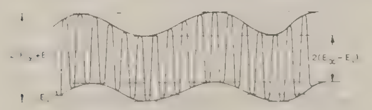

FIG 6 LOW FREQUENCY INTERFERENCE

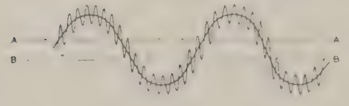

FIG 7 HIGH FREQUENCY INTERFERENCE

$$E_i = \frac{f_x \cdot E_x}{f_i} \times \frac{V}{2}$$

From this it may be seen that as

TABLE 1

Symptom	Possible Cause	Is effect eliminated by substitution of clean signal at same amplitude?	Remedy
Random variation not affected by signal level	Time Base jitter	No	Maintain counter
	F.M. on signal	Yes	Study bandwidth requirements. Consider change of test conditions
Random variation depending on signal level	Excessive A.M. or interference	Yes	Increase signal level or clean-up signal
	Severe distortion on input waveform	Yes	Reduce signal level and/or maintain counter
Reading steady but not exactly proportional to gate times	Gate waveforms too slow or not properly matched	No	Maintain counter
Reading steady at exactly twice true frequency	Severe distortion to signal waveform	Yes	Clean-up input signal
	Severe distortion caused in input amplifier	No	Reduce signal level and/or maintain counter
Slow drift of reading in constant direction	Drift to crystal oscillator due to temperature change after switch on	No	Use counter which has standby facility or fast warm-up oscillator
Slow cyclic variation of reading	Hysteresis of crystal oven control	No	Use external standard or counter with more refined oven control

continued on page 32.

DATA TRANSMISSION AND THE COMMUNICATIONS NETWORK

by R. B. Wilkinson, M.E.; Graduate I.E.E., Graduate N.Z.I.E.,

Based on a paper given at the Electronics Conference.

The various elements making up a data transmission link are examined briefly, followed by more detailed study of the transmission impairments and constraints which influence error rates and error detection. Special consideration is given to the effects of these constraints on the performance of frequency modulated medium speed (600/1200 baud) data modems.

1.0 INTRODUCTION

The two most important performance measures of a data transmission system are its speed and error rates, both of which depend on the modulation system and the channel properties. Generally speaking, a modern modem system on a "typical" telephone channel transmits data with a basic bit error probability of 10^{-4} or better. This figure can be improved upon with the use of special coding and error detection systems by a factor of at least 1000, giving a typical overall bit error probability of 10^{-7}.

Since the basic error rate depends on the modem and the channel, these parts of a data transmission system are of primary interest to a communications network administration. However, the final quality of a data link will be determined by the capability of the error detection system, a facility chosen by the user of the link.

The remainder of this paper will be mainly concerned with the modem and channel part of a data link although a few comments are made on error detection in section 11.

1.1 A Generalised Data Transmission System

A block diagram of a generalised data transmission system is shown in Fig. 1. Each block is considered briefly and characteristics examined.

Data Signal:

The baseband data signal consists of a train of pulses, each having either positive or negative polarity depending on whether it represents a mark or a space.

Low Pass Filter:

This filter band limits the input data signal, smoothing out sharp transitions and preventing sideband "foldover" distortion in modulation. It begins to shape the data pulse to a form suitable for transmission.

Modulator:

There are many modulation systems in use at present:—

(a) Binary on-off Amplitude Modulation (A.M.)
(b) Vestigial side-band A.M with suppressed carrier
(c) Binary Frequency Modulation (FM)
(d) Binary Phase Modulation (PM)
(e) Quaternary Phase Modulation
(f) Multilevel FM

References 1 to 9 describe and compare these various systems.

The most widely used systems of modulation are FM and PM. Frequency modulation is used in the 600 to 1200 baud (bits/second) range and Phase modulation for rates of up to 2400 bauds. The reasons for these preferences are given in section **1.2** where overall system performance is summarised.

Transmitter Band-Pass Filter:

This filter restricts the transmitter signal to the range of frequencies passed by the channel. This action avoids transmitting signal components which will not be received and prevents crosstalking into other channels using the same carrier circuit e.g. low speed error control data channel or voice frequency signalling. The low-pass and band-pass filters also shape the signal to a desirable form for transmission. This signal is applied to the channel where it is altered by additive noise and interference before reaching the receiver.

Receiver Band-Pass Filter:

This filter removes the noise components outside the band of interest and shapes the incoming signal. Its action is important in reducing the effects of impulsive noise.

Demodulator:

The demodulator translates the received data signal to a baseband form. Demodulation processes are perhaps even more varied than modulation processes and are covered in references on the latter.

Receiver Low Pass Filter:

This filter, not required in all systems, is used to remove unwanted demodulation products outside the band of interest and to provide further signal shaping.

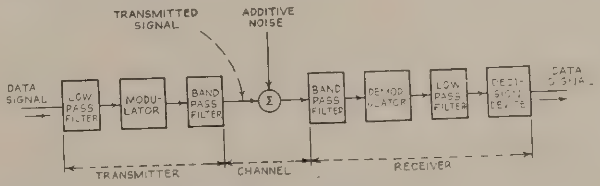

Figure One: Generalised data transmission system.

Decision Device:

The decision element samples the combined signal and noise at its input at discrete sampling instants and on the basis of each sample produces a mark or space symbol. Slicers or threshold detectors are commonly used as decision devices.

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Filter and Channel Response:

The filters are used to shape the signal pulse in such a way that the overall response of the transmission path, including the channel characteristics, to an applied data signal results in the specific signal required at the decision device.

The overall response is determined by the requirement that intersymbol interference at the decision device is minimum. Nyquist (9) has stated three response criteria which when satisfied meet this requirement. The most commonly used amplitude response is the raised cosine, described by the equation:

$$A(\omega) = \tfrac{1}{2}\left[1 + \cos\left(\frac{\pi \cdot \omega}{2\omega_1}\right)\right]$$

The corresponding phase characteristic is linear i.e. $B(\omega) = \omega T$. This characteristic has an impulse response which satisfies two of Nyquist's criteria, giving three sampling instants when the received signal value will be independent of any other pulse in the train.

In arriving at such an overall response the characteristics of the channel will be allowed for and the dominant design feature will be the receiver input filter. The response of this filter will be chosen to minimise the number of errors caused by noise. Having chosen the receive filter characteristics, the transmitter filters are then easily derived.

Transmission Rate

The maximum transmission rate is fixed by the shape of the channel response. If it is a raised cosine the maximum rate will be f_1, the cutoff frequency of the characteristic.

1.2 System Performance

Every data transmission system is subject to errors which may be caused by any of the following transmission impairments.

i Dropouts; amplitude and phase jumps and similar discontinuities
ii Impulse noise
iii White noise (random or gaussian)
iv Amplitude — frequency distortion
v Phase — frequency distortion
vi Echoes
vii Non-linear distortions
viii Carrier frequency error (frequency offset)

Items iv and v will be deviations from the optimum overall response assumed when designing the system.

The tolerance of a modulation system to any given combination of these impairments will define its range of applications.

Performance Ranking:

A considerable amount of theoretical and practical work has been carried out to obtain a "ranking" of the various modulation methods under each of the above impairments.

The results of Bell System experience are presented in Ref 9 p.238. When signal to noise ratios yielding a particular error rate for constant bit rate are compared, the ranking is (from Ref 10):

(i) Single-sideband AM with coherent detection
(ii) Double-sideband AM with coherent detection
(iii) Phase shift keying with differentially coherent detection
(iv) Frequency shift keying (Binary FM)
(v) AM with envelope detection

This ranking applied for both gaussian and impulse noise.

When all-round performance and complexity have been weighed it is found that frequency modulation is the most suitable method. FM is reasonably simple, provides good performance over a wide variety of channels and permits asynchronous operation. This versatility has made FM the most widely used form of data transmission in the USA and Europe. Binary phase modulation provides better noise performance, but at the cost of increased complexity which has limited its general use.

1.3 Frequency-modulated Data Systems

For the remainder of this study transmission impairments will be considered with particular emphasis on the performance of FM operating at 600 and 1200 bauds.

Modulation details:

CCITT specified modems modulate 1500 ± 200 c/s at 600 bauds and 1700 ± 400 c/s at 1200 bauds.

Studies show (Ref 1a) that for FM on normal telephone circuits the maximum reliable rate of transmission is just above 1200 bauds. The optimum frequency deviation is found to be about .66 of the modulation rate and spectral density studies (Ref 11) show that the most uniform energy distribution occurs with a deviation of 0.64 the modulation rate. Choice of carrier frequency depends on the attenuation and delay characteristics of bearer circuits.

2.0 MEASURED ERROR RATES

A considerable number of field trials have been conducted in Europe and the USA using various modulation systems on typical telephone connections. These tests have shown what bit error probabilities can be expected from practical equipment working over the many diverse circuit types making up a network. (Ref 1a, 12a, 13).

A study of these trials leads to the following generalizations:

i The bit error probability is seldom greater than 10^{-4}.
ii 70% to 80% of all data calls have lower error rates than the average (parts in 10^{-5})
iii 90% of all calls have error rates less than twice the average.

2.1 Error Causes

Under normal operating conditions for speeds up to 1200 bauds the major contributing error causes are dropouts and impulse noise. White noise and attenuation/phase distortion tend only to reduce the margin of immunity to impulsive noise. At higher speeds attenuation and phase distortion also begin to have a major effect. These and other transmission impairments are examined in the following sections.

3.0 DROUPOUTS

Dropouts are sudden severe attenuations or total loss of signal, and as such cannot, easily be guarded against in the modem.

In most modems a dropout causes a continuous mark or space condition to be received, which generates an incorrect message. Protection is obtained by using error detection and trouble detection systems.

A Bell system study showed that 20% of the errors on long distance calls were attributable to dropouts, 90% of which were less than 30mS long. Tests in Europe obtain similar results.

At this date the whole matter of dropouts is rather confused. From the few measurements which have been made no clear statistical distribution is discernable although the CCITT note some grouping of durations and causative elements. The greatest number of interruptions lie in the "less than 10 mS" category. This type of interruption is attributed to:

(a) Power supplies
(b) Changeover of carrier generators causing phase discontinuities
(c) Imperfections in the connection of measuring equipment.

The next largest category is in the range "over 300 mS".

Main causes are:

(a) Routine changeover to standby power
(b) Variation in mains power supplies due to weather
(c) Fading on radio links
(d) Maintenance operations involving faulty equipment replacement
(e) Certain cable repair work.

4.0 IMPULSE NOISE

Impulse noise mutilates transmitted signals and creates signals where none previously existed. However according to Ref 12, no clear experimental correlation between impulse occurrence and errors has been established because dropouts confuse the measurement results. The effect of an impulse is dependent on the system of modulation. In the case of AM an impulse causes direct amplitude modulation of the carrier, but for FM the effect is less obvious since an impulse injects wideband energy of random phase in relation to the carrier, into the system. For both cases the probability of error in a binary signal as a result of an impulse is found to be a function of impulse amplitude.

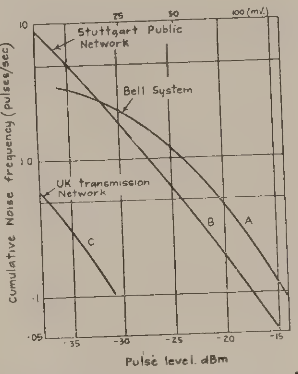
4.1 Impulse Magnitude and Causes

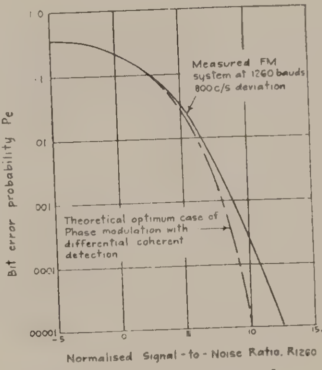
Impulses occur in bursts, which are themselves quite closely spaced. It is this feature which allows reliable data transmission at high speeds. Information is transmitted in blocks and due to the grouped nature of impulses a small percentage of blocks contain a large percentage of the element errors. This is discussed further in Section 11.

Noise shapes, amplitudes, and frequencies of occurrence are studied in references 2, 5, 9, 10 and 12. Figure 2 summarises noise pulse amplitude and frequency measurements made by Bell in the USA and S.E.L. in Germany on switched networks. The "probable" curve for the U.K. transmission system is based on figures from Ref 5. It is interesting to note that the Bell continental network is about 4 dB noisier than the Stuttgart public network. Although a curve is not shown, an S.E.L. crossbar P.A.B.X. gives a noise curve between 8 and 21 dB lower than that of the step-by-step system. S.E.L. note that the most important source of noise is the modulation of the selector contact current by vibration from adjacent two motion selectors. Such disturbances may have amplitudes up to 50 or 100 mV, and last for several hundred milliseconds. The vibration mentioned will tend to be a function of the mechanical structure of the switches, in particular of the stepping mechanisms and the wiper assemblies.

4.2 Protection Against Impulses

The most significant protection against impulses is a well designed receiver band pass filter as mentioned in section 1.





Left, Figure Two: Frequency of occurrence of noise pulses above a certain level.
Right, Figure Three: Bit error probability against signal-to-noise ratio.

It has been proposed that impulse effects can be reduced by inserting complementary phase delay networks at either end of the channel. At the transmitter the signal energy is smeared out in time and at the receiver the signal is reassembled in proper order again, or "de-smeared". Thus a signal passing through both networks will suffer little distortion, but an impulse passing only through the receiver network will be prolonged and reduced in height, thereby reducing the probability of an error. (The names "smear – desmear" and "chirp" are applied to this technique in radar.)

Experiments with an 800 baud system using recorded noise and two seventeen-stage delay networks showed that the impulse error rate could be reduced by a factor of 10, or an effective 5 dB reduction of the signal to noise ratio. (Refs 9, 10).

5.0 WHITE NOISE

In a "normal" telephone connection — i.e., one which is quite satisfactory for speech, white noise levels are low, certainly less than –50 dBm. However, from the data transmission viewpoint, crosstalk and far away echoes can be regarded as noise too, since they introduce a random element into the decision as to whether a bit is present or not. (Ref 12a).

5.1 Effect of Noise

In general, steady noise is not of great importance in pulse transmission since data transmission systems have inherently high white noise immunity. However, noise does introduce an element of indecision into the system, which is defined as a probability of element error for a given signal to noise ratio.

Signal to noise ratio for a data transmission system seems to be most usefully defined as signal to noise ratio for a noise bandwidth equal to the modulation rate, Rmr. This figure will be quoted.

In Fig 3 a measured result is given showing that the element error probability below pe = 0.01 is strongly dependent on signal to noise ratio because the curve has a very high slope. This has been predicted in theoretical studies (Ref 4). This strong dependence can almost be regarded as a threshold and so long as the signal to noise ratio is no worse than say –15 dB, the system will perform almost independent of white noise level — i.e. pe = less than 10^{-6}.

5.2 Noise Limits

Based on the foregoing data the CCITT recommend that signal to noise ratio Rmr be greater than 12 to 15 dB at 1200 bauds (Ref 5). A margin of at least 10 dB above this should be allowed to compensate for the various effects of delay distortion, attenuation and impulsive noise. (See following Sections). It should be noted that transmission loss becomes important in this way.

A tentative noise limit then, is given by the requirement that Rmr be greater than 22 dB for reliable operation.

5.3 Noise Magnitudes

In the Bell survey (Ref 12), it was shown that only 1% of the long haul connections measured exceeded noise values of –46 dBm in a 1200 c/s bandwidth. When related to transmission loss measurements, the worst likely signal to noise ratio was estimated. These measurements showed that less than 5% of long haul data calls experience 26 dB attenuation at a transmit level of –10 dBm. This gives a worst likely signal to noise ratio Rmr = 10 dB. This figure takes no account of any inter-dependence between high loss and high noise circuits.

5.4 Signal-to-Noise Ratio in New Zealand

Because of the dependence of Rmr on circuit attenuation and on noise level it is difficult to predict what S/N ratios will be typical in N.Z. Examination of worst case calls achievable under present P.O. planning practice suggests that less than 5% of 1200 baud data calls in New Zealand will have an S/N ratio worse than 18dB. The most extreme cases will have S/N of the order of 13 dB.

6.0 AMPLITUDE-FREQUENCY DISTORTION

Amplitude-frequency distortion is the distortion caused by variation of transmission loss with frequency. This effect alters the amplitude distribution of signal energy and effectively causes a reduction of the signal-to-noise ratio, or an increase in errors.

6.1 Magnitude of Attenuation Distortion

The Bell system survey resulted in the generalised attenuation characteristic shown in Fig 4. (Refs 5a, 12a). The most important feature of this characteristic is a linear slope attenuation between 1000 and 2900 c/s of on the average, 8 to 10 dB. This slope lies in the band used by data transmission systems. By comparing bandwidths and channel characteristics a similar generalised curve for New Zealand has been suggested.

6.2 Equalisation

The Bell system found it advantageous to use attenuation equalisers compensating a 4 dB slope between 1100 and 2100 c/s (their Mark and Space frequencies at 1200 bauds). This reduces the slope to 2.5 dB on an average call.

In Ref 1 it is commented that 6 dB slope equalisation between the Mark and Space frequencies resulted in a reduction of error rate by three, equivalent to a 1 dB improvement in signal to noise ratio. It is also mentioned that a mixture of pre- and post-equalisation gave an even greater improvement due to its influence on received noise.

Several modem manufacturers supply equalisers with their equipment, and one firm claims that its equipment can tolerate a 20 dB slope across the frequency band of interest.

7.0 PHASE-FREQUENCY DISTORTION

(Delay Distortion)

Delay distortion is the relative time displacement of the frequency components making up a signal. The effect of delay distortion on data transmission systems working at speeds of up to 1200 bauds is to increase the error rate by effectively increasing the "noise" interfering with each pulse. Delay distortion disperses the energy of each pulse in time, resulting in pulse overlap (intersymbol interference) and consequent degradation in performance. At speeds of 2400 bauds and upwards, delay distortion is the chief degrading factor. Low level, close-in echoes due to impedance mismatches can also be regarded as and treated as a form of delay distortion.

7.1 Delay Distortion — Magnitude

It seems reasonable to estimate delay distortion in the New Zealand network by using the delay distortion curves for three links of CCITT specified carrier in tandem since 90% of New Zealand's channel equipment conforms with the CCITT Specification. Delay distortion figures for CCITT type carrier channels used in the U.K., Belgium, France and Germany are given in Ref 5b. These figures have been used to draw the delay distortion curves of Fig 5, for three links in tandem. The U.K. and the German curves were extreme values.

It will be noted that the CCITT specified modem uses bands of frequencies which lie astride areas of minimum slope attenuation and nearly minimum delay distortion (Figs 4 and 5).

7.2 Equalisation

The effects of delay distortion are reduced by delay equalisation, and modems capable of operating at

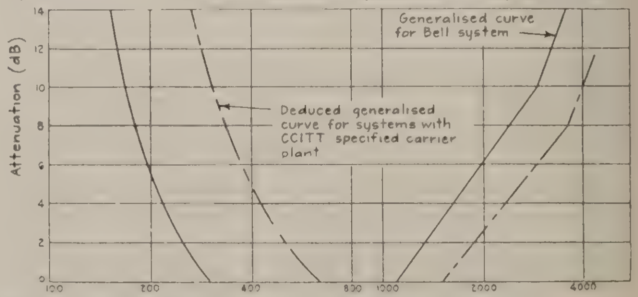


Figure Four: Telephone circuit attenuation—frequency characteristic.

1200 bauds may be supplied with equalisers — e.g. Datel 1A. If an equaliser were used to give curve (a) in Fig 5, then the signal to noise impairment should be less than 0.1 dB at 600 bauds and 0.7 dB at 1200 bauds.

A brief description of equalisation is given in Ref 9.

8.0 ECHOES

Echoes within a data connection are caused by impedance mismatches and unbalances, as in speech circuits. Very little quantitative information is available concerning typical echo magnitudes and effects, however a good planning principle appears to be that echoes at the receiver (listener echoes) should be at least 12 dB below the main received signal.

9.0 NON-LINEAR DISTORTIONS

Some non-linear distortion is caused by compandors (compressor-expander), which achieve an improved signal to noise ratio for speech signals by compressing the dynamic range of the signal before transmission and expanding the range of the received signal. When the compressor-expander characteristics do not match exactly signal distortions occur which may impair data signals, although not noticeably affect speech.

10.0 FREQUENCY OFFSET

Most carrier telephone systems use single sideband suppressed carrier transmission in which the demodulating carrier is not always locked in frequency with the modulating carrier. When the two carriers are offset, every component of the received signal is also offset and this alters the harmonic relationships of the received signal waveform causing severe distortions. Noticeable voice distortion occurs with offsets of 20 c/s. CCITT specifications (which are applied in New Zealand) allow an offset of ± 2 c/s which is not at all serious for wide band data transmission systems, but does affect narrow band frequency modulation.

11.0 ERRORS, DETECTION AND CONTROL

This is a very complex subject in which considerable fundamental research is still being carried out. In this Section only the important properties of errors and control systems will be highlighted.

For the purposes of study, errors are considered as being generated by statistical systems the properties of which can be determined by practical tests — e.g., Ref 14 and 15. Little attempt is made to determine causes, rather a detailed description of effects is sought.

11.1 The Nature of Errors

Research has shown that errors affecting medium speed data transmission can be grouped into two classes:

(a) Independent or isolated errors which obey the Poisson Law — i.e., the probability of one bit being changed is independent of any other bit being changed.

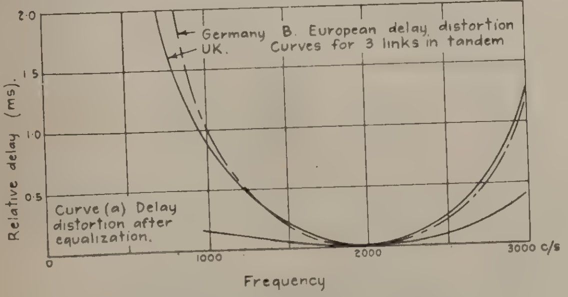


Figure Five: Relative delay distortion curves.

Burst type errors show a time dependence which extends over quite long sequences. It is not easy to find a probability law for errors within a burst; it is easier and more convenient to determine the burst lengths and separations. Measured results are given in references 1, 2 and 13.

11.2 The Use of Error Properties

When a data message is transmitted in discrete blocks at 1000 bauds, measurements show (Ref 1 Figs 6 and 7) that:

(a) Errors tend to group together — e.g., if one bit is in error then there is a 50% chance that another error will occur in the next 40 or 50 bits.

(b) Only a small proportion of blocks are subject to error, e.g., for block lengths of 60 bits or less, ½% of all blocks will be in error, and for blocks of 150 bits length or less, 1% or less will be in error.

This very strong grouping is fortunate, since it means that about 99.5% of transmission time is available for error free data transmission. The key problem is to detect the ½% of the time which is not error free.

Fortunately too, the errors which occur in blocks behave in a reasonably predictable fashion. Nearly all errors are caused by two or less error burst of length less than 20 bits each. 1, 2, 3 and 4 bit errors/block make up a very large proportion of all errors.

Hence an error detection system which will detect up to two bursts of length 20 and up to 4 bit errors/block will detect the majority of errors.

Errors within blocks are studied with the aid of P(m,n) curves. Ref 13, 14. P(m,n) is the probability that exactly m bits will be in error in a block of n bits. Such curves can be used to evaluate the effectiveness of an error detection system.

11.3 The Method of Error Detection

Error detection schemes rely on redundancy. In most methods the message is broken into message blocks to each of which is added a short block of redundant information. This redundant information is derived from the message block itself in such a way as to "highlight" as many of the probable changes that could result from error disturbances. The redundant information may be distributed through the message block or it may follow it in a transmission. The position, type and quantity of redundant information all determine the particular error sensitivities of the coding system.

At the receiver the redundant information is generated again, this time from the received message block (see Fig 6). If it differs at all from the received redundant information, then an error is detected.

The error detection process is used in two ways:

(a) To detect and correct.

(b) To detect and usually to order a retransmission.

Detection and correction restricts the range of redundant codes which can be used, since not only must the error be detected but the offending bits must be identified. This usually involves a large number of redundant bits and can significantly reduce the message transmission speed.

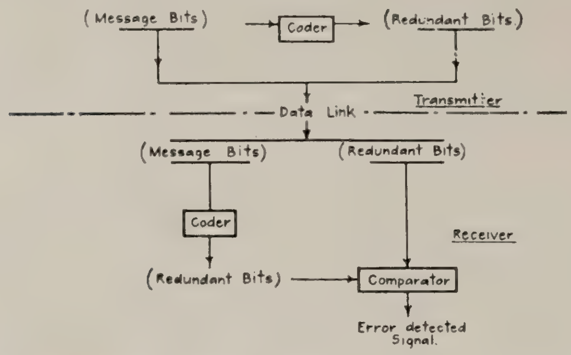


Figure Six: The error detection process.

The retransmission approach can be more efficient, since there is no need for identification of errors, detection only is required. The number of redundant bits is quite small.

Whenever an error is detected transmission is stopped and a retransmission ordered. In this way about 99% of transmission time is used for message transmission. This method is most widely used, particularly since the development of high speed reversible tape readers.

A third "error detection" process suggested by Marko and Aulhorn (Ref 2) is the trouble detector. Whenever line disturbances rise above a certain level, transmission is halted until they subside. This can result in unnecessary retransmission but it is "playing safe".

11.4 Error Detection Codes

There are many error detecting codes in use or being proposed, in itself a problem. Two code types stand out:

(a) Parity Checking Codes in which the redundant bits are obtained by "arraying" the message into a rectangular form and summing along the rows, columns and perhaps diagonals. The parity bits are derived by summing a row (column or diagonal) and making it up to an odd (or even) number with the parity bit. Such codes are effective with independent errors and the location of erroneous bits.

(b) Cyclic Codes, in which the redundant bits are obtained by various summations of the message bits using a feedback register system. The feedback interconnections in the register are defined by polynominal (e.g. $1 + X + X^6 + X^7 + X^{10}$) which establishes the pattern of sums taken. This polynominal determines the error detecting capabilities of the system. These codes are easy and comparatively cheap to implement and are highly efficient. They are particularly suited to burst error detection but are satisfactory for independent error detection. The coding polynominal is easily changed, which means that codes can be chosen to meet circumstances (Refs 5b and 13).

Parity checking codes are most commonly used in current British systems, however cyclic coding is planned for the next "generation" of equipment. As mentioned above, variety of codes is becoming a problem. It is being suggested (Refs 1 and 5b) that error control procedures should be standardised to facilitate interconnection of independent data systems via the switched network. This is profitable looking forward to a problem that has not yet arisen.

11.5 Error Detection Performance

Two examples are given, one of a parity check system and one of a cyclic system.

Parity System:

From Ref 2: 63 bit block made up of 42 information bits and 21 redundant bits (i.e. 67% efficient). In tests on the Stuttgart switched network at a block-error probability of .02 the measured undetected-block-error probability was 3 x 10^{-7}. In the worst cases retransmission times exceeding 10% were seldom observed.

Cyclic Coding:

In Ref 2 it is commented that cyclic coding would give an at least 10 times improvement on parity checking. In the U.K. suggestion (Ref 19) a 260 bit block is proposed with 240 information bits, 16 check bits and 4 control bits (92.3% efficient). With a block error rate of .005 (½%) the mean undetected error probability will be about 10^{-9}.

American experiments with a 31 bit block containing 10 check bits (68% efficient) gave an undetected-block-error rate of 3.1 x 10^{-8} with an initial word error rate of 4.7 x 10^{-4}, an improvement factor of 1.5 x 10^4. (Ref 13).

11.6 Conclusions on Error Detection

As mentioned in section 1 the final error rate of a data transmission system will depend on the error control system. The basic block-error probability can be reduced by a factor of 10^{-4} without much difficulty. Present practice in other countries allows the modem user complete freedom in his choice of error control equipment. However, there is a move to standardise on one type of error control, cyclic coding and retransmission. This will clear the way towards flexible interworking between any two data sets via the switched network.

12.0 DATA TRANSMISSION AND THE OPERATOR CONTROLLED NETWORK

In the literature no comment is made about the effects of operator interference in the circuit. However in most of the countries where tests have been made direct dialling was not entirely automatic at the time. Hence it is possible that operator induced errors are included in the figures.

12.1 The Effects on the Operator

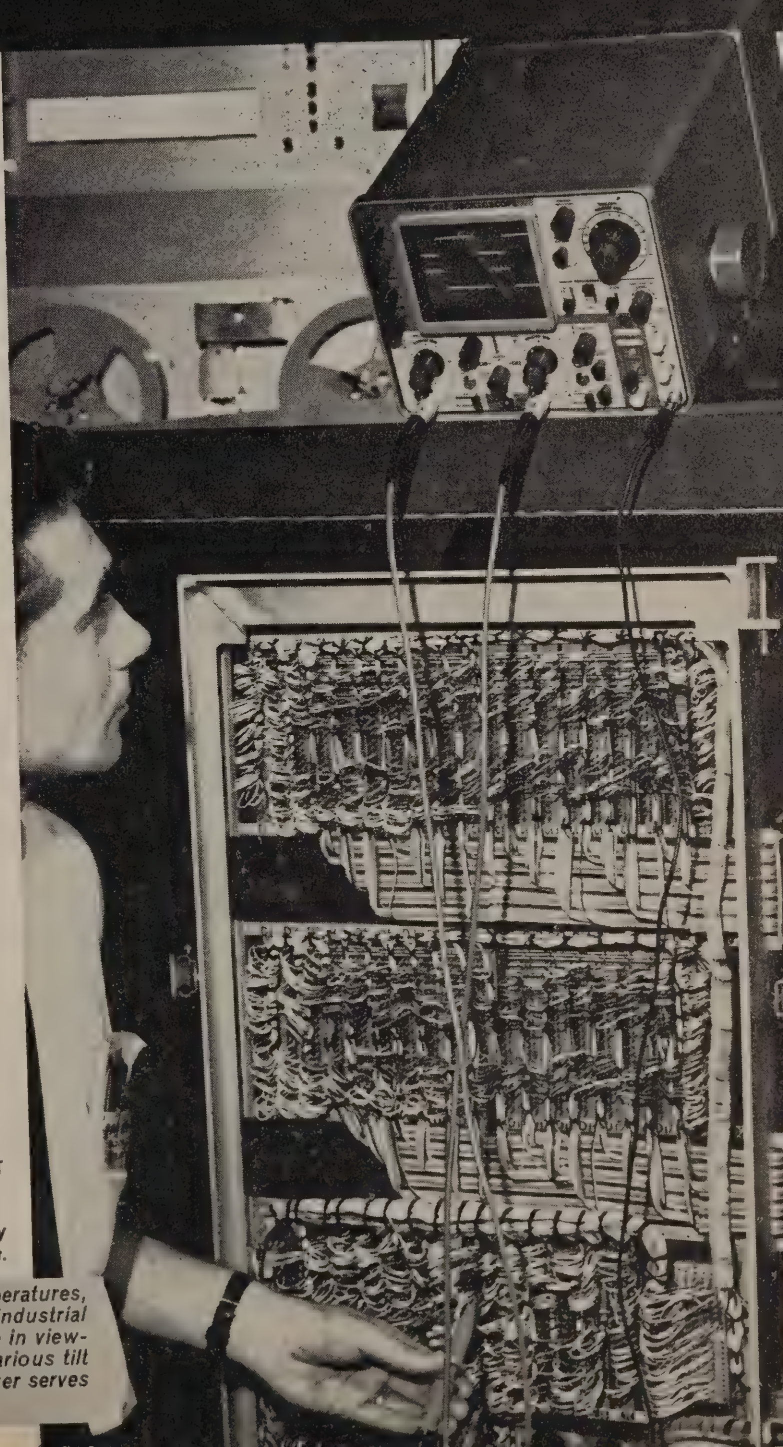
The operator will normally be at the sending end of a data call. If transmit levels are set according to CCITT recommendation then the maximum possible data signal level at the operating position is –8.5 dBm. In general the level will be about –12 dBm. The acoustic shock when switching briefly across these levels is tolerable.

continued on page 31

TEKTRONIX ®

type 422

portability



The Type 422 is dimensionally proportioned for comfortable portability and on-the-job convenience.

Small Size — with maximum overall dimensions of $6\frac{3}{4}''$ high x 10" wide x $17\frac{4}{5}''$ deep, including panel cover and handle, making it easy to carry anywhere, even through a revolving door.

Light Weight — ∼21 pounds, with panel cover and included accessories.

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Operating (without batteries)	—15°C to +55°C, to 15,000 ft.
Storage (with batteries)	—40°C to +60°C
Operating (with batteries)	—15°C to +40°C, to 15,000 ft.

No fan needed, yet it runs cool and stays clean.

Versatile Performance—with bandwidth of dc-to-15 Mc, sensitivity to 10 mv/div, sweep speed of 0.5 μsec div to 0.5 sec/div, and dual-trace operation in a compact instrument. Ch 2 X10 to 1 mv div (AC only).

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Quality — same ±3% calibration accuracy, value engineering, careful manufacture, strict quality control, and international engineering support as other Tektronix laboratory oscilloscopes.

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Type 422

Designed to handle the shocks, vibrations, temperatures, and other adverse conditions encountered in industrial environments. Proportioned to fit the job for ease in viewing and operation. Carrying handle adjusts for various tilt positions and is a sturdy support stand; front cover serves as accessory and storage case.

AWA MANTEL RADIO

MODEL MS100

CIRCUIT AND SERVICE DATA

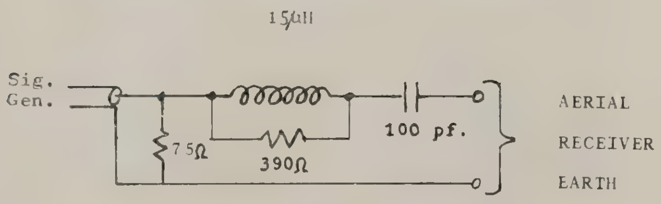
1) Remove the control knobs by pulling straight off.
2) Remove the cabinet back and disconnect the aerial lead from the metal foil.
3) Remove the two screws securing the rear of the chassis from inside the cabinet; and the two screws securing the front from underneath.
4) The chassis can now be removed. Sufficient length has been allowed on the chassis and speaker interconnecting wires to permit chassis removal without disconnecting the speaker.

ALIGNMENT:

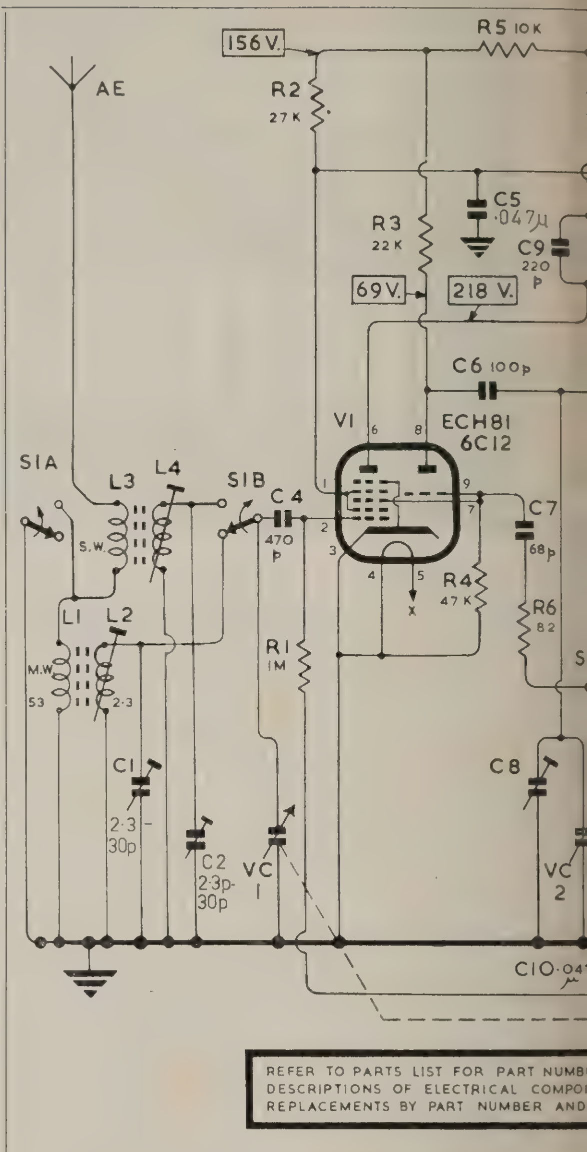
1) EQUIPMENT REQUIRED:

- a) A signal generator covering the range of 450 Kc/s to 20Mc/s modulated 30% at 400 c/s or 1000 c/s.
- b) An audio output meter capable of reading 500mW @ 3 ohms.
  (A multimeter on the 2.5V A.C. range will indicate a power output of 500mW when the voltage reads 1.225 across a 3ohm speaker).
- c) A non-metallic trimming tool suitable for adjusting the I.F. and R.F. coils.
- d) A 100pf dummy aerial.

2) INTERMEDIATE FREQUENCY ALIGNMENT:



- a) Set the signal generator to 455 Kc/s.
- b) Ensure that the tuning gang is closed.
- c) Unscrew the secondary core of T2 (top of can) a few turns.
- d) Connect the signal generator output via a 0.01 mf. capacitor to grid 1 (pin 2) of V2 (EF89).
- e) With the volume control set at maximum gain, adjust the primary core (bottom core) on T2 (2nd I.F.) for maximum output.
  Adjust the signal generator attenuator to keep the output at 500mW or less.
- f) Adjust the secondary core (top core) on T2 for maximum output.
  Do not re-adjust primary.
- g) Connect the signal generator output via a 0.01 mf capacitor to grid 1 (Pin 2) of V1 (ECH81).



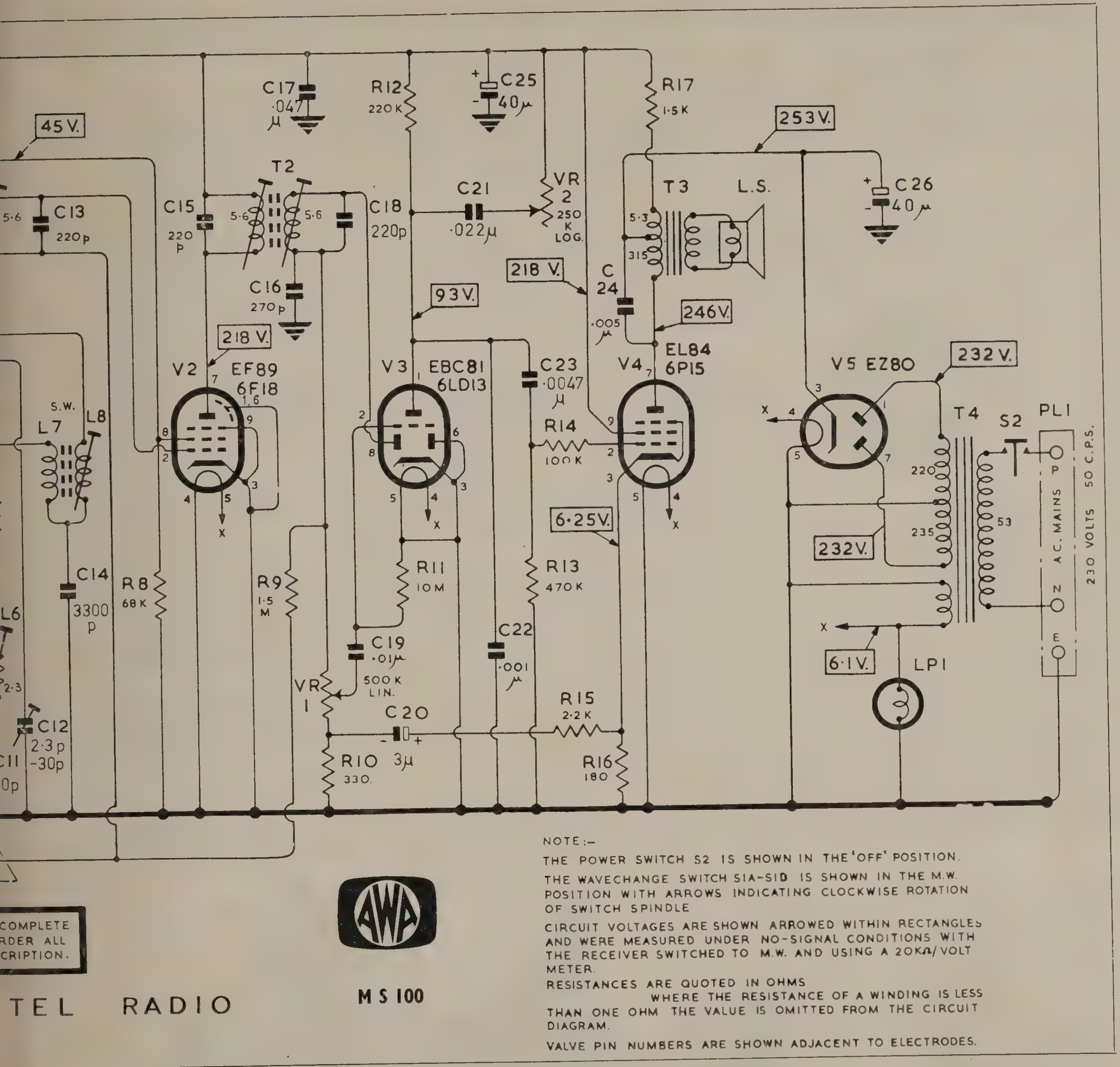
CIRCUIT DIAGRAM •

- h) Adjust the primary core (bottom core) on T1 (1st IF) for maximum output.
- i) Adjust the secondary core (top core) on T1 for maximum output.
  Do not re-adjust primary.

3) R.F. ALIGNMENT:

N.B.

1) Short wave **oscillator** adjustments must be made before medium wave. If short wave is adjusted, medium wave must be re-adjusted.
2) Disconnect the aerial plate during the R.F. alignment. It is also necessary to remove the dial scale from the cabinet if recalibration is required.
3) The calibration marks are in the form of blank squares interrupting the horizontal line immediately above the frequency figures.
   They appear at:



NOTE:–

THE POWER SWITCH S2 IS SHOWN IN THE 'OFF' POSITION.

THE WAVECHANGE SWITCH S1A–S1D IS SHOWN IN THE M.W. POSITION WITH ARROWS INDICATING CLOCKWISE ROTATION OF SWITCH SPINDLE

CIRCUIT VOLTAGES ARE SHOWN ARROWED WITHIN RECTANGLES AND WERE MEASURED UNDER NO-SIGNAL CONDITIONS WITH THE RECEIVER SWITCHED TO M.W. AND USING A 20KΩ/VOLT METER.

RESISTANCES ARE QUOTED IN OHMS

WHERE THE RESISTANCE OF A WINDING IS LESS THAN ONE OHM THE VALUE IS OMITTED FROM THE CIRCUIT DIAGRAM.

VALVE PIN NUMBERS ARE SHOWN ADJACENT TO ELECTRODES.

MEDIUM WAVE: 600Kc/s; 1000Kc/s; 1364Kc/s; 1500Kc/s.

SHORT WAVE: 6.7Mc/s; 11.811Mc/s; 15.228Mc/s; 17.794Mc/s.

a) Connect the signal generator via the dummy aerial to the aerial and earth leads of the receiver.

b) Close the gang and set the pointer to the left hand datum point on the dial scale. This corresponds to the black vertical line at the start of the blank strip.

c) Tune the pointer to the 6.7Mc/s calibration mark (switch on short-wave; signal generator tuned to 6.7Mc/s) and peak the short wave aerial and oscillator coil **cores** for maximum output.

Adjust the attenuator on the signal generator to keep the audio output at 500mW or less.

d) Tune the pointer to the 15.288Mc/s calibration mark (signal generator tuned to 15.228Mc/s) and peak the oscillator gang trimmer and the short wave aerial coil **trimmer** for maximum output.

e) Repeat steps (c) & (d) until no further improvement in output is obtainable.

f) Tune the pointer to the 600 Kc/s calibration mark (switch to medium wave; signal generator tuned to 600Kc/s) and peak the medium wave aerial and oscillator coil **cores** for maximum output.

g) Tune the pointer to the 1364Kc/s calibration mark (signal generator tuned to 1364Kc/s) and peak the medium wave aerial and oscillator coil **trimmers** for maximum output.

h) Repeat steps (f) & (g) until no further improvement in output is obtainable.

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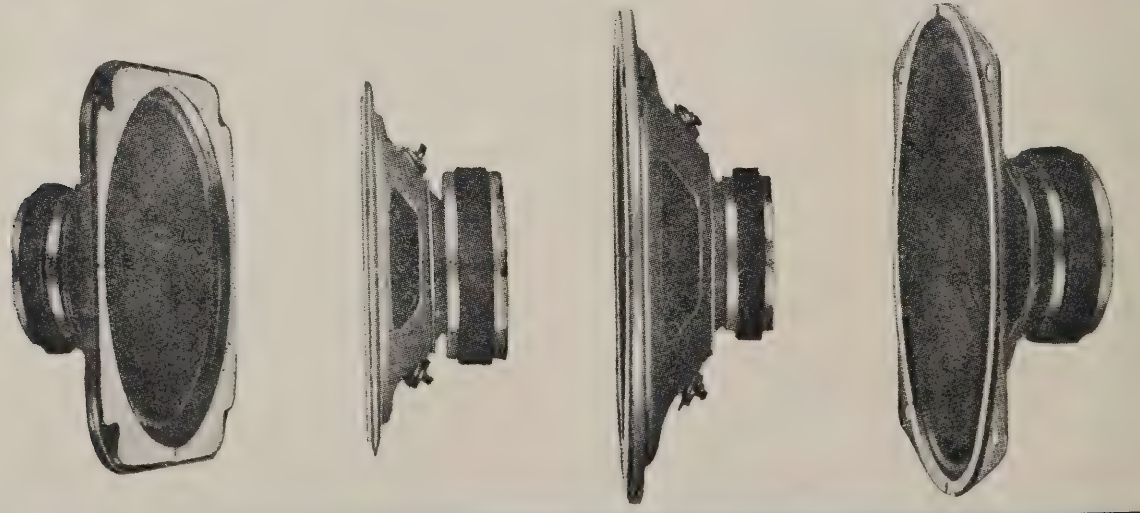
SPECIFICATIONS

	C5-3D — C5-3G	C5D — C5G	C3D — C3G	C4D — C4G
Power Handling Capacity:				
D	3 Watts Peak	3½ Watts peak	3 Watts Peak	3½ Watts Peak
G	3½ Watts Peak	3½ Watts peak	3 Watts Peak	3½ Watts Peak
Diaphragm	F 266	F 274	F 269	F 272
Fundamental Resonance	155 c.p.s.	135 c.p.s.	235 c.p.s.	140 c.p.s.
Frequency Response	150 c.p.s. — 6 K.C.	130 c.p.s. — 7 K.C.	220 c.p.s. — 7 K.C.	135 c.p.s. — 7 K.C.
Voice Call Impedance	15 ohms at 400 c.p.s. 3.5 ohms at 400 c.p.s.	15 ohms at 400 c.p.s. 3.5 ohms at 400 c.p.s.	15 ohms at 400 c.p.s. 3.5 ohms at 400 c.p.s.	15 ohms at 400 c.p.s. 3.5 ohms at 400 c.p.s.
Air Gap Flux Density:				
D	7,800 Gauss	7,800 Gauss	7,800 Gauss	7,800 Gauss
G	11,000 Gauss	11,000 Gauss	11,000 Gauss	11,000 Gauss
Total Gap Flux:				
D	13,000 Lines	13,000 Lines	13,000 Lines	13,000 Lines
G	18,400 Lines	18,400 Lines	18,400 Lines	18,400 Lines
Principal Dimensions:				
Overall diameter of diaphragm housing	5 1/16″ x 3 1/16″	5″	3 9/16″ x 3 9/16″	4⅛″ x 4⅛″
Diameter of baffle opening	4¾″ x 2¾″	4 5/16″	3 3/16″	3 11/16″
Diameter of Voice Coil	⅝″	⅝″	⅝″	⅝″
Depth from pad ring to rear:				
D	1 9/32″	1 9/16″	1¼″	1 13/32″
G	1 13/32″	1 11/16″	1⅜″	1 17/32″



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ENQUIRY 440. USE FORM AT REAR.

AN INTRODUCTION TO

The Technique of Voltage Measurements*

PART II

Measurement of AC Voltage in Composite Circuits

AC circuits may exhibit simultaneously and at a single measuring point a DC voltage component and AC voltage components with different frequencies. The indicating system of the voltmeter is mostly blocked from the DC voltage component by a built-in isolating capacitor (Fig.9); the value of the DC voltage component must not exceed the permissible operating DC voltage given for this capacitor in the specifications, where the erroneous statement "sum of the DC voltage and the superposed AC voltage" is often found; in the operating frequency range there is no drop of AC voltage across the capacitor!

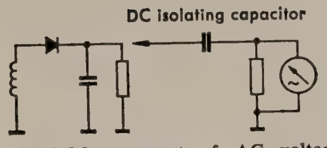

Fig. 9 Measurement of AC voltage in composite circuits.

If various frequency components are present at the measuring point, a wideband voltmeter will indicate the arithmetic (peak-responding voltmeter) or geometrical (rms meter) sum of all the discrete amplitudes within its frequency range. Selective voltmeters, i.e. test receivers or analyzers, are required if spectral resolution of the discrete amplitudes, especially of adjacent frequencies is desired.

Low-pass or high-pass filter networks, or in the simplest case RC or CR sections with a suitable cutoff frequency, are sufficient for separating the widely spaced frequencies (e.g. RF-AF components). A CR section with a cutoff frequency of about 200 Hz is sufficient for isolating the hum from the noise component in measuring the noise voltage on an AF amplifier, although standard networks will be required for standard measurements.

If the value of the hum voltage on a filter capacitor is to be measured, the gradual variations in the DC voltage, which is high in relation to the AC voltage, would result in the pointer becoming very unsteady. An RC section with a cutoff frequency of 10 Hz steadies the deflection without introducing any significant error into the measuring result. It is necessary to make certain that the shunt impedance of such a high-pass or low-pass filter network is large in relation to the source impedance and small in relation to the input impedance unless

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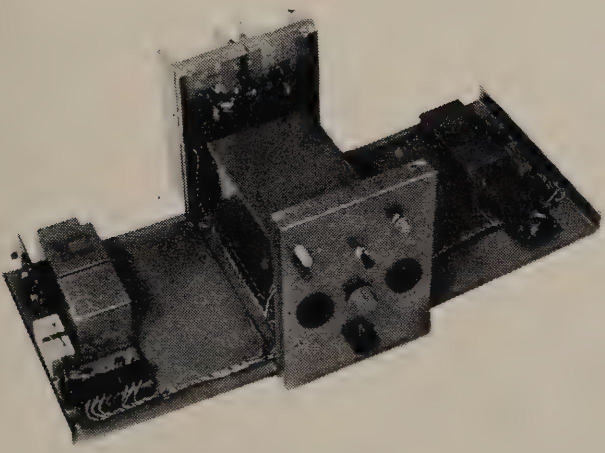
Introducing the REDFERN SINE WAVE INVERTER



Designed for professional users, features high frequency stability and low waveform distortion. Suitable for tape recorders, audio equipment, chart recorders, T.V. sets, etc. A stable unijunction transistor multivibrator drives the silicon output transistors. A special ferro-resonant output transformer produces a sine wave output. The characteristics of this transformer limits short circuit loading giving complete transistor protection. The unit is made to highest standards, all transformers encapsulated. Silent operation. Remote control and reverse polarity protection. Voltage reg. switch. Specification Max load 150 w. input 22-28V. D.C. output 230V. 50Hz Sine Wave. 5Hz Distortion 7½ to 14% depending on load characteristic. 12½" x 7⅝" x 11¼".

This illustration shows the inverter 'opened-up' for ease of servicing. This is a double 'flip-back' chassis.

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it is intended to operate directly into the input impedance itself, so making it part of the network.

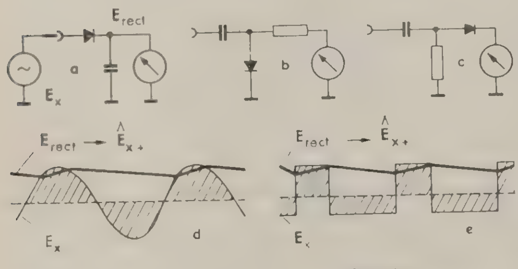
The transformer inputs of voltmeters are not usually isolated against direct current; the unknown must not here exhibit a DC component unless it is small in relation to the unknown.

Their low DC resistance either loads the DC source heavily or the transformer will be thermally overloaded. If necessary, such inputs should be externally wired to an isolating capacitor whose reactance for errors smaller than 0.5% at the test frequency must be more than 10 times smaller than the input impedance Z^{in}.

Since the majority of voltmeters or multimeters without any amplifier are also without isolating capacitors, the DC voltage appears superposed on the AC voltage measurement.

Waveform and Types of Diode Rectifiers

In order to measure and display a characteristic parameter of the instantaneous value of an AC voltage which varies with the angular frequency ω, the unknown must be rectified and the resulting pulsating DC voltage integrated as a function of time with a time constant that is larger than the period of the test frequency but smaller than the variation in time of the parameter, which should still be readable. Depending on the type of rectifier used, the parameter will be the rms, average or peak value.



E_{rect}
a
E_x
b
c
$E_{rect} \rightarrow \hat{E}_{x+}$
$E_{rect} \rightarrow \hat{E}_{x+}$
E_x
d
E_x
e

Fig. 10 Half-wave peak rectification: (a) series connection, (b) and (c) shunt connections, (d) and (e) voltage characteristic at charging capacitor in presence of sine-wave and square-wave voltages.

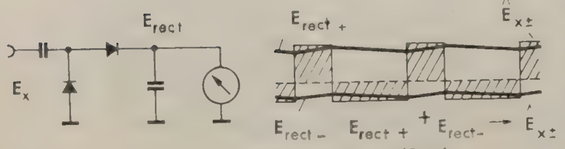
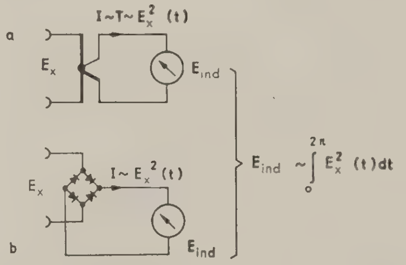


Fig. 11 Full-wave peak rectification.

Peak response is technologically easy to realize and frequently employed. A capacitor with a minimum time constant is charged by the diode rectifier to a value as close as possible to the peak value of the respective amplitude. The discharge time constant must be such that the voltage drop remains as small as possible up to the peak of the next period (Fig. 10, 11).

If diode rectifiers are operated outside of the curvature of their characteristic and without a charging capacitor, a value proportional to the average value of the unknown voltage will appear following the integration of the pulsating DC voltage by means of an RC section or the intertia of the meter



$I \sim T \sim E_x^2\ (t)$
a
E_x
E_{ind}
$I \sim E_x{}^2 (t)$
E_x
b
E_{ind}
$E_{ind} \sim \int_0^{2\pi} E_x^2\ (t)dt$

Fig. 12 Average-responsive rectification (arithmetic evaluation; diode current linearized through R).

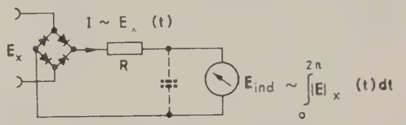


Fig. 13 Rms evaluation: (a) thermocouple, (b) diodes in square-law region of characteristic

The rms value represents the time integral of the squared voltage (Fig. 13). The classical transducer for rms measurements is the thermocouple. Since the thermo-electric voltage of the thermocouple is proportional to the heater temperature T, a thermo-electric voltage proportional to E^2/R^{heater} results, thereby satisfying the squared integral. There are also circuits in which diode rectifiers are operated in the strictly square-law region of their characteristic $(1 = E^2)$, as well as a variety of trick circuits which through various shortcomings have failed to gain general acceptance.

If the time characteristic of an AC voltage is strictly sinusoidal, a fixed relationship will obtain between rms value, average value and peak value:

$$E^{peak} = E^{rms}\ \sqrt{2} = E^{avge}\ \frac{\pi}{2}$$

$$E^{rms} = E^{peak}\ \frac{1}{\sqrt{2}} = \frac{E^{avge}}{\sqrt{2}} \cdot \frac{\pi}{2}$$

$$E^{avge} = E^{rms}\ \sqrt{2}\ \frac{2}{\pi} = E^{peak}\ \frac{2}{\pi}$$

If the time characteristic exhibits deviations from the sine, the above values will vary according to the nature and magnitude of the deviations. For a square-wave voltage with the duty cycle 1:1, for instance, the three values will be equal; for a very short needle pulse the rms value will be much smaller than the peak value and the average value will be much smaller still.

Irrespective of the type of rectification, voltmeters are calibrated in rms values of a sine signal. (An exception is provided by special pulse voltmeters calibrated to give peak-to-peak readings.) This means that voltmeters with diode rectifiers which respond to the peak or average value will not provide a correct indication of the rms value unless the unknown voltage is truly sinusoidal. If, on the other hand, it exhibits distortion, it is possible that the error will increase up to the value of the distortion factor k according to the type and position of the harmonics:

$$\pm\ Error^{meas} </= k\ (\%)$$

In order to determine the rms value of an AC voltage, voltmeters with peak-responding diode rectifiers will only be suitable if the distortion is smaller than the acceptable error. Before an exact determination of an AC voltage can be made, one must also know the type of diode rectifier and of the waveform of the unknown voltage.

RF wideband voltmeters and RF probes are usually provided with peak-type diode rectifiers. They are suitable for measurements on tuned circuits, low-impedance or capacitive sources, signal generators and four-terminal networks, which usually have low distortion. They are not suitable, for instance, for measuring the AC supply voltage or heating voltage in electronic equipment (iron core saturation in AC supply transformer), or for measuring the output voltage of AF final stages, where distortions of about

10% regularly occur, and errors of this order are intolerable.

In the case of full-wave peak rectification (as depicted in Fig. 11), wideband voltmeters may be used for measuring pulse voltages. In order to determine the peak-to-peak value the reading must then be multiplied by $2\sqrt{2} = 2.82$. The permissible duty cycle is always limited and depends on the unknown voltage; the limits are stated in the description covering the respective equipment.

Peak-type diode rectifiers have yet one other peculiarity which may easily become a source of error: their input impedance over a period is not constant but depends on time. A pulsating current which flows only during the charging phase of the capacitor loads the source at this instant far more than its average value over a period of time (Fig. 14).

If the peak-type diode rectifier is arranged in the input of a voltmeter (i.e. not, say, at the output of a precision amplifier), the resistance of a resistive source must be <0.3 to <10kΩ, depending on the type of voltmeter, if the error is not to exceed 1%.

In the case of higher values, the error due to the charging capacitor failing to reach the peak value of the unknown voltage is accompanied by the condition that the unknown voltage exhibits disagreeable sine-wave deformation (Fig. 15).

Capacitive sources or tuned circuits are far less sensitive and are only loaded with the average value of the input current. Purely inductive sources, which are few and far between, are only suitable for measurements with peak-type diode rectifiers if $\omega L < 30\Omega$. The mathematical function of the input current is very complex and the actual pulse values differ greatly according to the type of instrument and the unknown voltage. The forward flow angle of the current varies between about 40° and 100° and the pulse current between 10 and 30 times the average value of the current.

With rising frequency a permanent current is superimposed on the pulse current. This permanent current is caused by the reduction of the dynamic non-reactive resistance of that part of the load resistor to which the unknown AC voltage is applied, and by current losses occurring in the insulation of the sockets and probe tip. The pulse-like component of the resistance is independent of frequency and is swamped at high radio frequencies by the falling continuous component. Typical input impedances (without a plug-in voltage divider) are:

		Vacuum diodes	Semi-conductor diodes
		Ω	Ω
Pulse-like component		100	100 k
Rms input	100 kHz	1 M	100 k
resistance	at 100 MHz	30 k	15 k

In the region of commercial and audio frequencies a preference is often shown for average-value rectification, which is easily realizable up to about 1 MHz (beyond this the inevitable circuit and diode capacitances transform the average-value rectifier back into a peak-type rectifier).

Calibrated in rms values, the average-value rectifier has the property that, even if the waveform of the unknown voltage is greatly distorted, it will more readily indicate the rms value that the peak-type rectifier ($\text{Error}^{\text{meas}} < k$).

Average-responsive rectifiers are frequently encountered in multimeters and amplifier-rectifier voltmeters for low and medium radio frequencies, and lend themselves well to measurements on AF and carrier frequency generators for up to about 1 MHz, as also for greatly distorted heater voltages and similar variables. The average-responsive rectifier is not suitable for measuring pulse voltages because it cannot indicate either their peak or their rms value with adequate exactitude.

The selective application of mutual-type thermocouples as correct rms transducers is mainly limited to precision measurements and to transfer methods as used in calibrating voltmeters. Having high internal power drain and being very sensitive to overloading and slow in response, conventional thermocouples are not very suitable for laboratory instruments, although they will occasionally be found in laboratory instruments with fast transducers protected from overloading.

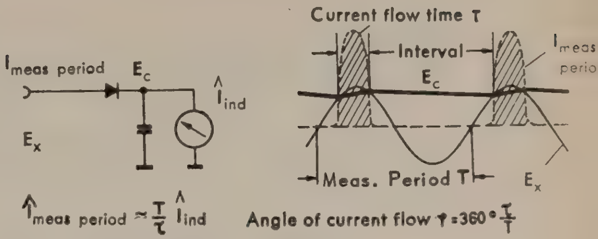


Fig. 14 Input current of peak-responsive rectifier.

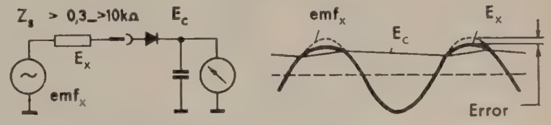


Fig. 15 Error of measurement and distortion of unknown voltage with peak-responsive rectifier inputs and large source impedance.

If thermocouples are connected directly to a source, they will correctly determine the rms value even of pulsating voltages. However, if connected to the end of a precision voltage amplifier, a certain ratio between peak value and rms value, i.e. the crest factor, must not be exceeded or the amplifier will be overloaded. In other words, the duty cycle of a pulse voltage cannot be arbitrarily large. The same also applies with respect to diode rectifiers that are operated in the square-law region of their characteristic; in the case of a large crest factor there will here be a danger of overloading.

Part III—next month

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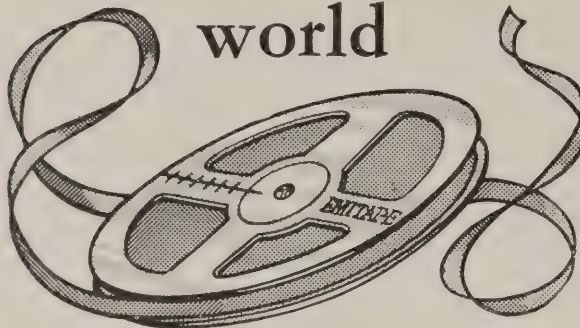

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ENQUIRY 351. USE FORM AT REAR.

A Simple Photometer

for Oscilloscope Photography

by **B. R. Webster***

Photographic recording of oscilloscope displays has become a common requirement in the present day electronics laboratory. When only a few photographs are required, a polaroid Land camera, giving immediate prints, is generally the most popular. Apart from the more obvious advantages, the immediate availability of the print from this type of camera facilitates empirical determination of exposure time without the long delay introduced by normal film processing.

By taking several trial pictures of a display, corrections can be made to the absolute and relative brilliance of both trace and graticule in order to obtain satisfactory results from a given exposure time and lens aperture setting.

If, however, a large number of photographs are required, it becomes very much more economical to use a 35 mm camera. Furthermore, the 35 mm film lends itself much more readily to the production of projector slides should these be needed.

But the use of this film introduces certain problems. For consistent results, it is usually advisable that all exposures should be made with the same lens aperture and shutter speed; and it then becomes essential that the illumination of the graticule and the brilliance of the trace remain constant. The setting of the graticule illumination is fairly simple, since the illumination control can be set to a predetermined position; but the trace intensity is more difficult, for it varies with writing speed and repetition rate as well as brilliance control setting. Using a 35 mm camera, individual exposures cannot be examined immediately for the purpose of adjustment to the appropriate oscilloscope controls, so that a suitable light monitor must be used.

An ordinary photographic exposure meter is unsuitable because it is not normally sufficiently sensitive rather than the brightness of the trace. An effective and its reading is proportional to the total night emitted solution to the problem can be achieved, however, by constructing a simple device operating on the principle of the grease spot photometer, which is capable of balancing the intensity of the light from two sources.

---

*Measuretest by Marconi Instruments Ltd.

The construction of the photometer is shown diagramatically in figure 1. It is made from the foil backed tissue paper which forms the interior wrapping in a cigarette packet, a piece of thin black card, and a small quantity of transparent adhesive tape.

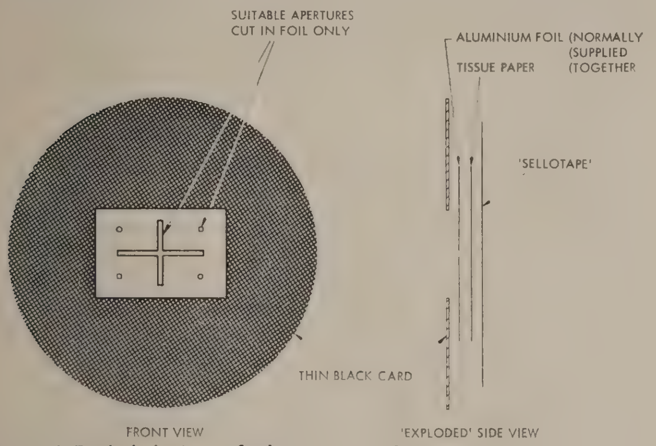

Figure 1 Exploded view of photometer unit

To make the photometer:—

(1) Cut the black card mask to fill the viewing aperture of the oscilloscope completely, and then cut out a rectangular opening at the centre of the card to take the photometer — for 5″ c.r.t. screens, a hole 1½″ x 1″ is suitable.

(2) Cut slot apertures in the foil only (see diagram), taking care not to damage the paper.

(3) Using the transparent tape, secure the photometer over the hole in the card, with the tissue paper in contact with the card. As well as mounting the photometer on the mask, the transparent tape must be made to keep the foil in contact with the tissue paper where the apertures have been cut.

The photometer mask is then placed in position over the face of the oscilloscope's display screen as shown in figure 2. All that is now required is a means of balancing the light from a representative portion of the trace against that from a standard source. This is very easily arranged by the use of a small lamp which can be clipped to the inside of the camera hood.

To obtain a consistent level of illumination on the camera side of the photometer, three requirements must be met:—

(a) The distance between the lamp and the photometer must remain constant for all measurements because the illuminations is proportional to the square of the distance.

(b) The brilliance of the source must also remain constant. (Monitoring the lamp current gives sufficient accuracy for this purpose).

(c) The light falling on each side of the photometer should have as nearly as possible the same chromatic content. (A filter of the same material as that used for the c.r.t display normally gives good chromatic balance).

In order to determine the required lamp current, some test exposures must be made. Owing to the difficulty of repeating a given setting of the oscilloscope's brilliance control, the most satisfactory way of setting up the system initially is to adjust for an acceptable visual display on the c.r.t. screen, and then take a series of photographs varying the exposure time or the lens aperture over the expected range. Having ascertained the optimum setting for the camera, this setting is used for all subsequent photographs, the photometer being utilised to repeat the trace brilliance.

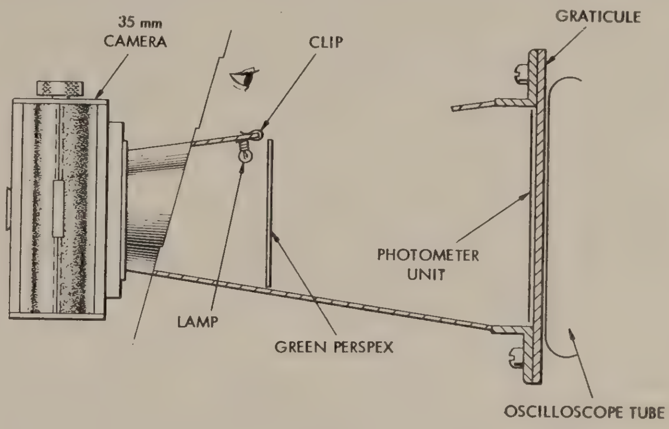

Figure 2 Arrangement for balancing the two light sources

The next step is to find the lamp current corresponding to the trace brilliance used for the exposure tests. Taking care not to disturb the setting of the oscilloscope's brilliance control, the photometer mask and the lamp are placed in position together with the filter if one is being used. With zero lamp current passing, the shift controls of the oscilloscope are adjusted to bring a representative portion of the trace into coincidence with one of the slots in the photometer foil —it will, of course, show up as a bright line. The lamp current is then adjusted to the value where slot appears to vanish; i.e., the light from the lamp exactly balances that from the trace.

Having determined the appropriate lamp current for the camera setting, all subsequent photographs can be exposed correctly by reversing the procedure in the previous paragraph. The required trace is displayed, and the photometer is placed in position. With the brilliance well up, the shift controls are adjusted to bring part of the trace into coincidence with a slot in the photometer foil. The lamp current is set to the predetermined value; and the brilliance control is adjusted for apparent disappearance of the trace. The photometer can then be removed and the exposure made.

If the photographs are to be made with an illuminated graticule, a similar overall procedure should be adopted for setting up the brilliance of the graticule illumination. It should be done separately from the balancing of the trace brilliance with no filter over the lamp. Interference from the trace can easily be avoided by simply moving the trace away from the photometer slots by means of the shift controls.

NEW SOUND TECHNIQUE

by Roy Herbert, LPS Science Correspondent

Underwater sound detection systems capable of locating a single codfish at a range of 1.2 miles could result from research by scientists at Birmingham University.

They are investigating the potentialities of what are called "Non-Linear" Acoustics. Laboratory experiments show that the technique could give a completely new look to underseas communications and research and to the exploitation of the sea's riches.

Sound waves are already used for transmitting signals under water. But so far usable band widths have been small. In addition, highly directive or narrow beams cannot easily be produced.

To get a directional beam using relatively low frequencies — which are necessary to obtain ranges greater than a few hundred metres in water — large and expensive equipment is required. What is needed for good communications is a pencil-like beam of low frequencies with a wide available band.

The Birmingham scientists have discovered that they can produce a highly directional sound beam by arranging for two "primary" trains of sound waves to impinge on each other. The "secondary" sound waves which result are at lower frequencies as well as being propagated in a narrow beam.

For example, primary frequencies of about 300 kc/s will produce a three degree beam at a frequency of ten kc/s. Furthermore, the secondary frequencies can be varied over a band width of about ten kc/s. Width of the transmitted beam can be kept constant over a large frequency range.

Only small devices are needed for the primary frequencies. For sweeping or fanning, the beam can be moved by varying the angles at which the two primary beams meet.

In describing the system that could detect a single codfish, the scientists quote primary frequencies of about 100 kc/s, giving a two degree beam over a secondary frequency range of seven to 30 kc/s.

If, for instance, a 20 degree sector was to be observed by the beam it could be split into ten segments. Each segment would be marked by a different band of frequencies transmitted in a pulse down it. Any echo would be "finger printed" to show exactly in which segment the target lay.

At these frequencies, or wavelengths, the range of a target would be narrowed down to less than one feet — thus an object as small as a fish would show up.

It is possible, too, to propagate frequencies that will penetrate the bed of the sea thus give information on its geological characteristics that may be valuable in exploration. In general greater power is needed for such a system than is used in sonar now. Though there appears to be no way round this, it is not an important disadvantage in many applications. The Birmingham group is carrying out further experiments on devices using a locally generated sound wave to amplify incoming signals, to analyse them and to show their angle of return.

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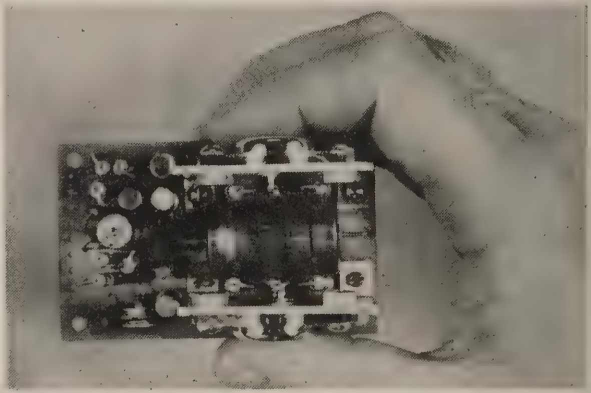

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Book Reviews

PROBABILITY AND INFORMATION THEORY WITH APPLICATIONS TO RADAR

P. M. WOODWARD, published by Pergaman Press. 133 pages.

This book explains in easy stages how the theory of probability applies to electronics, communications, and in particular radar. The book summarizes in an elementary way the simple classical theory of probability distributions, leading up to characteristic functions, entropy and the Gaussian law, and then gives a mathematical description of waveforms, including noise, and a concise but comprehensive account of Shannon's information theory which is a recent development of probability theory as applied to communication problems.

The experimentalist relies a great deal on physical intuition, and often appears to by-pass much detailed mathematical theory. The author believes that much of this intuition is in fact theory, but that treatments are too often overlaid with algebraic complications which obscure the simple ideas and principles. For this reason he has kept the book as lucid and fundamental as possible, and as such it will be of great value to research workers in radar and electronics, and to all those with a background knowledge of elementary mathematics and an interest in the subject.

THEORY OF ELASTICITY & PLASTICITY, by H. M. Westergaard; this edition published by Dover Publications Inc. 176 pages.

This is a compactly-written account of the fundamental ideas and mathematical techniques of the theory of elasticity and some consideration of plasticity. It is designed chiefly for graduate students in civil or mechanical engineering, but is broad enough to interest anyone with a background in the mechanics of materials, and there is strong emphasis on practical field problems. All mathematical processes are fully explained.

The author sketches the history of investigation from Galileo to the Hoover Dam, a project to which he served as a consulting engineer. After a discussion of stress, strain, displacement, Hooke's law, the basic equation of elasticity, and so on, he furnishes a systematic exposition of methods of solution of certain problems, employing such concepts as the strain potential, the Galerkin vector and the twinned gradient, and treating such problems as hollow cylinders and spheres. He demonstrates the value of general solutions in terms of arbitrary functions and adapts them to yield some highly interesting special cases.

ELECTRONIC AMPLIFIERS FOR AUTOMATIC COMPENSATORS

by D. Ye. Polonnikov, published by Pergamon Press. 312 pages

Amplifier technology is developing rapidly and many significant advances are taking place. Electronic valve amplifiers, however, will remain of value in several fields for some time to come because of their comparatively low noise level and high input resistance. This applies particularly to high-sensitivity amplifiers and to those intended for operation in adverse temperature conditions.

This volume describes the principles of design of electronic amplifiers used in control and monitoring systems, and the factors governing their reliable and accurate operation. It covers general amplifier design and methods of measuring the principal parameters of amplifiers and it also discusses the design of a.c., d.c. and high-sensitivity voltage and current amplifiers.

Emphasis is placed exclusively on the design of amplifiers for operation in automatic control systems and the problems involved in their operation in such systems. The book is particularly important because it is one of very few which are devoted exclusively to the problems of automatic compensator amplifier design. It is written at a technical level applicable to undergraduates and graduates to whom it will be valuable for both study and reference. It will also be extremely useful to engineers engaged in the design of electronic equipment for monitoring and control systems.

NON-LINEAR TRANSFORMATIONS OF STOCHASTIC PROCESSES

Editors: P. I. Kuznetsov, R. L. Stratonovich and V. I. Tikhonov, published by Pergamon Press. 493 pages.

Comprising a collection of papers by various authors, this volume contains a wealth of information on the theory of stochastic processes with special reference to the field of radio engineering. The papers cover both theoretical and practical aspects of this subject. The first chapter contains papers which develop the mathematics of stochastic processes and the methods of linear and non-linear transformation. Those in the next three chapters are devoted to the solution of common problems in the field of radio and control engineering relating to the effect of stochastic processes on non-linear systems and devices.

The general methods which are used are equally applicable to the solution of other problems. Finally, there is a chapter containing a selection of articles illustrating the synthesis of optimum systems.

Scientists and mathematicians will find this book valuable and, as in certain quarters there is considerable belief in stochastic methods in economic planning, it could also prove interesting and informative to economists.

OPERATIONAL METHODS IN NONLINEAR MECHANICS, by Louis A. Pipes, published by Dover Publications Inc. 99 pages.

The book presents a collection of problems whose methods of solution are applicable to those non-autonomous differential equations (where the independent variable, t, appears explicitly) that are frequently encountered by technologists.

The author presents some useful methods for the solution of certain classes of important nonlinear technical problems by applying them to typical problems in the fields of physics and engineering. The methods considered are essentially of two different

continued on page 33

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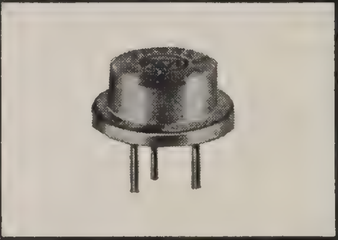

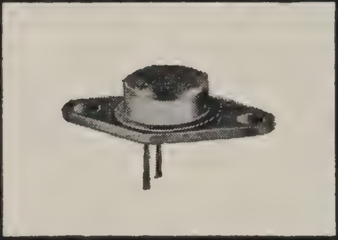

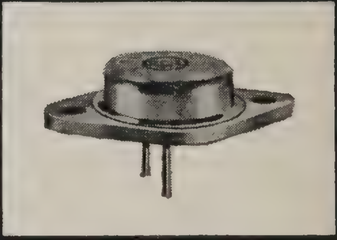

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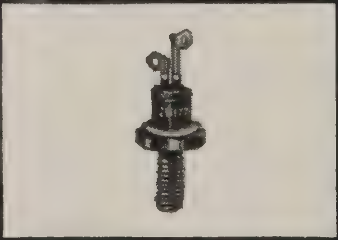

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ENQUIRY 429. USE FORM AT REAR.

continued from page 18

Data Transmission and the Communications Network

12.2 **Errors Induced by an Operator**

An operator can either introduce attenuation into a circuit or introduce interference by speaking. F.M. is fairly immune to level changes of the first kind, but when an average operator speaks across a line the speech power level is –10 dBm. The speech energy falling in the modem frequency range (1700 ± 400) would be several decibels below this.

Nevertheless speech would amount to severe impulse distortion and lead to an increase in the bit error probability. Most of the resulting errors would be detected and cause retransmission.

Assuming that all operator induced errors are detected the effect will be that the block-error rate is trebled. This follows from the fact that a 2-second interruption every three minutes amounts to about 1% of the time being unavailable for transmission. Other system defects result in ½% of time unavailable (sec. 11.2). However, this does not mean that the undetected block-error is trebled too, it may only double.

13.0 **INTERNATIONAL DATA TRANSMISSION**

Operating conditions for international data transmissions are still being evolved. The CCITT has made a recommendation (Ref 56) concerning data transmissions at 200, 600 and 1200 bauds which has been adopted on the COMPAC system.

13.1 **Leased Circuits**

For leased circuits it appears that the organisations controlling international circuits have accepted responsibility for equalisation of their circuits to the standards required. At present the type of equaliser and the distribution of equalisation along an international connection is still being decided, but this does not affect the user.

13.2 **Switched Connections**

In the case of switched data connections it has been shown that on COMPAC:

(a) Switched data transmission at a speed of 600 bauds is possible using an international connection with no restrictions.

(b) A switched data system at a speed of 1200 bauds is possible using one to three intercontinental circuits, with certain reservations on the national arrangements — e.g. a direct line to a group centre.

These comments apply to the Datel 1A modem system, which meets the CCITT specification.

It is noted that a switched intercontinental Datel service is already in operation from Britain and is planned by Canada.

14.0 **Conclusion**

The factors affecting the operation of a data transmission system have been considered, with particular emphasis on the transmission impairments which influence modern performance over a switched connection. The operating conditions likely to be found in New Zealand are no worse than those accepted by users of data modems in other countries. They are better than the conditions used by the designers of modem equipment.

Although error control functions are built into the users equipment there appears to be a good case for standardising error control systems and methods of coding. This will ensure a uniform quality of error detection and to some extent avoid interworking problems as the use of data transmission equipment develops.

Acknowledgement

The author wishes to thank the Engineer-in-Chief of the New Zealand Post Office for permission to prepare and present this paper.

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SINGLE PHASE—COHERENT TONE BURSTS

By Robert Anderson*

Research and testing in physiological and psychological fields have developed a need for tone bursts generated on command from a push button. Among the many uses for such bursts is the generation of control pulses to actuate a stroboscopic light source in flicker-fusion tests. Where it is not necessary that the bursts be phase coherent, a simple push button connected as in Figure 1 is adequate. In most applications however, phase coherence is a primary requirement. For these, the arrangement shown in Figure 2 is recommended.

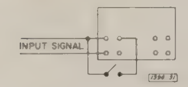

Figure 1. Simple connections for single bursts.

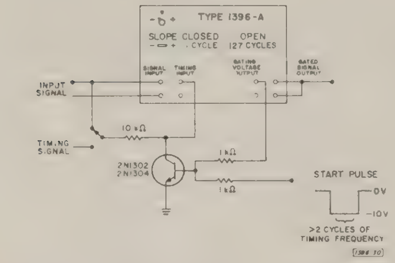

Figure 2. Connections for producing phase coherent bursts.

The transistor in the timing input circuit serves as a gate which is held in a low-resistance (10 ohms) saturated state by the positive gating voltage present between bursts. This gating voltage is normally used to synchronize an oscilloscope. The saturated transistor then forms a voltage divider with the 10-kΩ resistor such that no appreciable input signal is applied to the TIMING INPUT terminals. The instrument is thus locked in a state of no output (closed gate). Application of a negative start pulse turns the transistor off causing its collector-to-emitter resistance to become much greater than 10 kΩ and thus applying the input signal to the TIMING INPUT terminals which in turn starts the closed gate counting.

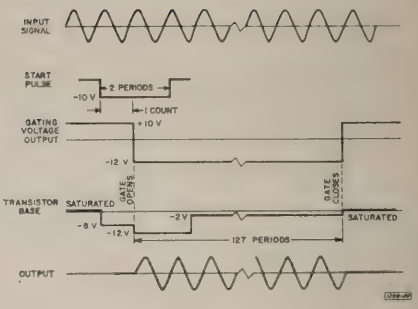

Figure 3. Timing diagram for a 120-period burst.

After the timing circuits have received one count the 1396-A main gate opens, starting the tone-burst. The gating voltage becomes negative when the tone-burst starts, and it, therefore, helps the start pulse hold the transistor in the off state so that when this start pulse ends the gate is held open by the gating voltage. When the "open count" number of cycles has been reached the 1396-A main gate closes and the gating voltage becomes positive so that the timing signal is stopped at the same time the tone-burst ends and the instrument is again locked in a condition of no output.

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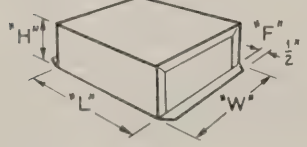
*Engineering Notes Radio General Co.

RADIO CHASSIS



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CHARACTERISTICS OF ELECTRONIC COUNTERS

Continued from page 12

fi increases the amplitude of Ei necessary for interference to affect the reading is reduced almost proportionately. A practical asymptote is provided by the need to exceed the hysteresis voltage. The characteristic given in figure 8 shows clearly the change in sensitivity with frequency ratio and demonstrates the need for extreme care in circumstances when high frequency interference is possible.

At frequencies which are low, compared with fx, the amplitude of interference may be approximately as large as that of the wanted signal (section a of the curve). As the relative frequency of interference increases, the maximum permissible level reduces (section b of the curve) until it reaches the limit set by the basic sensitivity of the trigger circuit (section c of the curve). Finally, some additional protection is provided by the upper frequency response limit of the instrument (section d of the curve).

This article has drawn attention to limitations in the performance and use of electronic counters when applied to the accurate measurement of frequency. Using a well-designed instrument it is possible at the present state of the art to carry out measurements accurate to one part in 10^8 on an entirely routine basis and it is certainly possible to improve on this figure if care is taken with regard to the sources of error discussed. When readings are inconsistent or show a measure of random variation, reference to the table one may help to identify the cause and also to indicate the remedy.

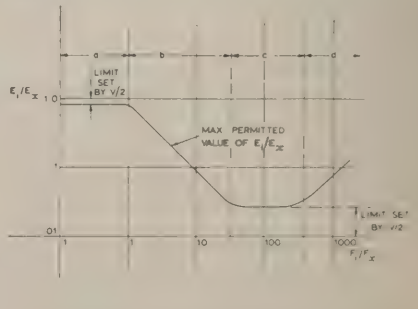

FIG. 8 FREQUENCY DEPENDENCE OF INTERFERENCE IMMUNITY

LISTENING POST

by Godfrey Gray

The following list of stations beaming programmes to the Pacific area was compiled during a recent survey of the shortwave bands. Many of these stations transmit programmes in English. All times are GMT and frequencies in kilocycles.

5955	France	1800 - 2000
5960	France	0600 - 0700 0800 - 0900
5970	Radio Canada	0830 - 0945
5985	VOA Dixon, USA	0845 - 1600
6005	Radio Moscow	1800 - 1930
6020	Holland	0600 - 0730
6050	HCJB Quito	0700 - 1000
6090	Sydney, Australia	0300 - 1400
6110	BBC, London	0500 - 0800
6135	Papeete, Tahiti	0300 - 0800
6140	Perth, Australia	1030 - 1600
6150	Melbourne, Australia	0815 - 1500
7120	BBC, London	0600 - 0845
7150	BBC, London	0600 - 0845
7190	Radio Australia	0700 - 1215
9510	BBC, London	0500 - 0800
9520	Radio New Zealand	0900 - 1145
9525	Holland	0600 - 0900
9540	Radio New Zealand	0600 - 0845
9560	Radio Australia	0645 - 0915
9575	Rome, Italy	2030 - 2115
9620	France	0600 - 0730
9620	Radio New Zealand	1700 - 1945
9630	Radio Canada	0830 - 0945
9640	BBC, London	0600 - 0845
9660	Brisbane, Australia	2000 - 1400
9680	Melbourne, Australia	2200 - 1400
9685	Voice of Germany	2110 - 2200
9745	HCJB Quito	0700 - 1000
11710	Radio Australia	0645 - 0915
11730	Holland	0600 - 0900
11795	Voice of Germany	0645 - 0945
11820	Radio New Zealand	0600 - 0845 0900 - 1145
11825	Papeete, Tahiti	0300 - 0800
11840	Radio Australia	1800 - 2115
11855	FEBC, Manila	0830 - 1030
11875	Radio Japan	0930 - 1030
11880	Radio Australia	2000 - 2215
11915	HCJB, Quito	0700 - 1000
11925	Voice of Germany	0845 - 0945
11955	BBC, London	0700 - 0845
15110	Radio New Zealand	2245 - 0545
15165	Voice of Denmark	0700 - 0800
15165	All India Radio	1000 - 1100
15205	Voice of Germany	0645 - 0945
15230	Melbourne, Australia	2215 - 0815
15235	Tokyo, Japan	0930 - 1030
15240	Radio Australia	0015 - 0645
15275	Voice of Germany	0845 - 0945
15280	Radio New Zealand	2000 - 0545
15330	Radio Australia	1800 - 2115
15360	Radio Moscow	0800 - 1500
15425	Perth, Australia	0015 - 1000
17705	All India Radio	1000 - 1100
17800	Switzerland	0900 - 1045
17810	Holland	1200 - 1600
17810	FEBC, Manila	2200 - 0015
17835	Radio Peking	0830 - 0930
17845	Voice of Germany	0845 - 0945
17850	Radio Moscow	0800 - 1400
17880	Voice of Germany	0645 - 0945
21480	Holland	1200 - 1430
21490	Voice of the West, Portugal	0730 - 0900
21520	Switzerland	0900 - 1045
21560	Rome, Italy	1145 - 1300
21570	Holland	1000 - 1430
21730	Radio Norway	1100 - 1215

OTHER STATION NEWS:

SOUTH AFRICA:– The latest schedule of Radio South Africa lists the following transmissions in English: To North America from 2330 - 0325 on 11900, 9675; to Africa from 2100 - 2155 on 15205, and to Europe from 2200 - 2255, also on 15205. Because signals from Africa have to pass through the highly ionized auroral zone, reception of Radio South Africa in New Zealand is irregular, and usually poor.

PAKISTAN:– Radio Pakistan appears to have dropped the 17950 outlet from their English transmission at 0830. The programme is still heard on 21590, but no frequencies are announced. Another English transmission can be heard at 0215 on 11885, following a half hour programme in Urdu.

UNITED NATIONS:– United Nations Newsreel, broadcast at 0845 from the VOA relay station at Honolulu, is now heard Tuesdays – Saturdays on 15370. This frequency replaces 15180.

BOOK REVIEWS

—continued from page 29

types: perturbation and sequence. Wherever possible operation procedures based on Laplace transform theory are introduced.

Pipes begins by offering a sample problem of dynamics to show how operational methods expedite the solution of nonlinear differential equations. He then discusses an operational adaption of the Lindstedt-Liapounoff method of successive approximations. This is followed by a method of reversion based on an algebraic procedure that reduces nonlinear differential equations to a system of linear differential equations. In another chapter, operational techniques are adapted to a sequence method connected with Lalesco's nonlinear integral equations. Pipes also covers problems of subharmonic resonance, applying operational methods to a series electric circuit and an inverted pendulum and to a mechanical oscillator.

Standard Printed Circuit Boards

(This is a partial range available ex stock)

Small Reflex Broadcast Receiver	11/6	ea
Mullard 10-10 Amp	17/6	ea
,, preamp	18/–	ea
,, Wideband Tuner	20/–	ea
,, 3 watt Amp	12/6	ea
RCM Digitrio Transmitter	21/6	ea
,, Rec, Dec (3 and 4)	17/6	ea
,, Servo	22/6	ea
,, Proporational Brake	5/–	ea
RTUH 65/T3	12/6	ea
Electronics Australia 65/09	13/–	ea
65/p10	11/6	ea
65/P12A	14/–	ea
66/R4	13/–	ea
R. E. and C. Transistor Amp	16/6	ea
Small Reflex Broadcast Receiver	11/6	ea
In general small boards	10/–	approx
medium boards	15/–	,,
large boards	20/–	,,

Kitsets Available Ex Stock

Mullard	Mullard 10-10 Amplifier includes printed circuit boards, components, transformers, punched chassis and cover, sockets, valves and Mullard stereo sound systems booklet. Price £38/10/0 ea.
R. E. & C.	R.E. and C. Stereo transistor amplifier (see R.E. and C. Sept. 65) includes printed circuit boards, components, transistors, unpunched cabinet, etc. Price £31/0/0 ea.
Kitronix	Kitronix small Reflex Broadcast Receiver (See R.E. and C. Sept. 66) includes printed circuit boards, components, transistors, etc. Does not include output socket, case, earpiece. Price 73/6 ea.

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New Products

LOW NOISE TUNNEL DIODES

Mullard now offers two new S-band germanium tunnel diodes. Using these new devices, amplifiers can be made with noise figures of only 3.8dB compared with about 4.5dB for similar amplifiers using other tunnel diodes. Immediate applications for these diodes, the first of their kind to be manufactured in the U.K., will be found in low-noise amplifiers of the type used in the latest solid-state multi-channel microwave communication links.

They are designed for use at frequencies up to 4Gc/s. Minimum cut-off frequencies are 6 and 10Gc/s for the two types at present available (AEY13 and AEY16 respectively). Typical negative resistance is 50 ohms, typical series resistance is only 0.9 ohms and the noise constant is only 1.3. The valley voltage is 300mV with a typical peak/valley ratio of 11.

The extremely small junction capacitance which is essential in devices of this type is achieved by using a tin/arsenic alloy bead only 15μm in diameter to reduce the amount of electrolytic etching required. This also increases robustness.

The diode housing measures only 1.78 mm diameter by 1.4 mm long. It has been designed to give a low inductance by using a thin ceramic annulus of small diameter, and by making short connections of rectangular cross-section foil to connect the p-n junction to the housing. The use of rectangular cross-section foil, rather than circular cross-section wire, also increases the mechanical strength of the device.

ENQUIRY 317

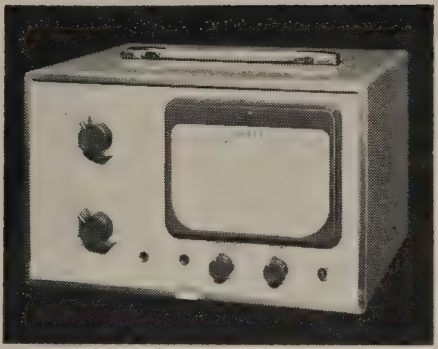
* * *

NEW, HIGH-STABILITY MARCONI VOLTMETER

The instrument, Electronic Voltmeter Type TF 2604 has been announced by Marconi. It enables precise measurements of a.c. voltages from 25 mV to 300 V in the frequency range 20 c/s to 1,500 Mc/s. The d.c. voltage range is 10 mV to 1,000 V, and resistance can be measured from 0.2Ω to 500 MΩ.

Four optional accessories increase its use. High voltages up to 30 kV d.c. and 2 kV a.c. can be measured with plug-on d.c. and a.c. multipliers. For measuring voltages on a coaxial line, there is a plug-on T-connector for the a.c. probe; an accurately matched 50-ohm coaxial terminating load is also available. The design means changes in the mains supply voltage by as much as 10% will cause a deflection change of less than 4 mV at full scale on all ranges.

A well-proven push-pull circuit is used to drive the meter, each half consisting of a valve amplifier and cathode follower. The probe used for a.c. measurements houses a disk-seal diode rectifier of an advanced type. A low capacitance of only 1.5 p.f. short transit time, and a 3,000 Mc/s resonance frequency, together with a small cylindrical lightweight probe head, make possible the frequency response of up to 1,500 Mc/s. A special plug-on ground connector is also supplied to facilitate the making of the ultra-short connection necessary at the higher frequencies.



ENQUIRY 408

* * *

PRECISION POTENTIAL DIVIDER

With the advent of commercially available Digital Voltmeters with a rated accuracy of the order 0.01%, and also the possible application of the Zener Diode as an accurate and stable Reference Voltage Standard, it has become necessary to be able to check the calibration of these devices by potentiometric measurements.

It follows that since the most accurate potentiometers have a self-contained range of less than 2 volts, use must be made of some form of potential divider.

The usual accuracy of such instruments is 0.02% which compares most unfavourably with that of the potentiometers. Thus the development of a voltage ratio box of 0.001% accuracy comparable to that of the main potentiometer is important.

SPECIFICATION

200 ohms per volt.
Output 1 Volt for the following input voltages:— 1 - 2 - 5 - 10 - 20 - 50 - 100 - 200 - 500 - 1000.
100% overload for short periods is permissible.
The accuracy of Ratio is 0.001% or better.
Oil immersed and sealed in a metal tank.
Copper terminals with shrouded heads to minimise thermo electric e.m.f. due to handling.
Two thermometers are fitted.
Terminals are mounted on polished insulated pillars for the maintenance of high insulation.
All coils are wound from the same sample of Manganin Wire.
The absolute temperature coefficient of resistance is of the order 0.001% °C but the differential coefficient of Ratio is virtually zero over the range 18°C to 25°C.
Dimensions: 41cms. x 38cms. x 27cms, overall.
Weight: 38.5kg. Oil Filled. Without Oil, 11.5kg. approx.

ENQUIRY 390

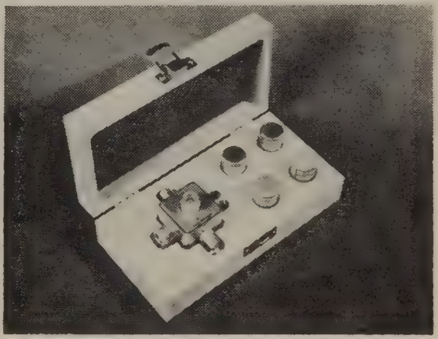
VSWR MEASUREMENTS

A series of complete, pre-packaged kits for making VSWR measurements is being introduced by Telonic Engineering Co.

Utilizing Telonic's "Rho-Tector" VSWR detectors, the kits contain everything necessary for making the impedance comparisons basic to VSWR measurements in RF and microwave devices.

Besides the detector, which comes in any one of five models operating in a frequency range from 1 MHz to 4 GHz, each kit contains two standard matched terminations and two mismatches.

With the standard Telonic microwave terminations available, VSWR values from 1.00/1 to 6.00/1 may be measured, with maximum error due to unbalance as low as 0.633%, at impedances from 25 to 100 ohms.



The Rho-Tector VSWR detectors in each kit are equipped with special glass-bead "N" type connectors which overcome the severe shortcomings of standard connectors at the higher frequencies specified for the Telonic devices. The special connectors permit maximum mechanical stability and insure accuracy of VSWR measurements over long periods of use.

ENQUIRY 398

* * *

T-2 FLAT-END LAMPS

Chicago Miniature Lamps offer the following definite advantages over conventional lamps of this type.

The T-2 lamps are but a quarter inch in diameter to permit extreme compactness in the design of panel boards.

The flat-end bulbs permit the filament to be mounted close to the end of the bulb so that it provides greater light intensity from the end of the bulb and far higher end-footcandles for a brighter signal than can be obtained from conventionally designed lamps.

These lamps are available in a wide range of rated voltages from 4 volts to 120 volts. The latter is the smallest standard 120-volt incandescent lamp, permitting the design of highly compact equipment and eliminating the need for costly, space-consuming transformers. This 120-volt lamp can be incorporated into equipment at a cost saving as great as 67% over conventional lamps.

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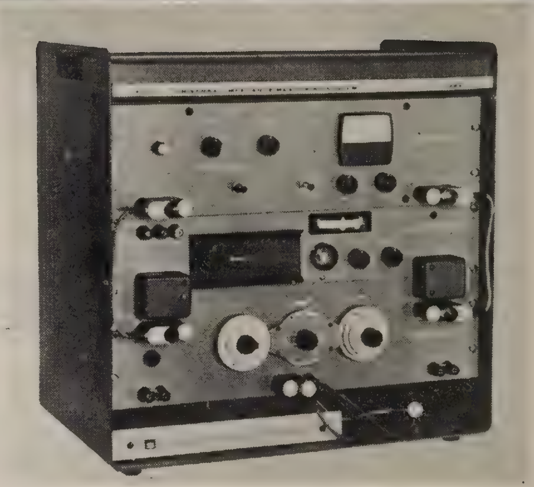
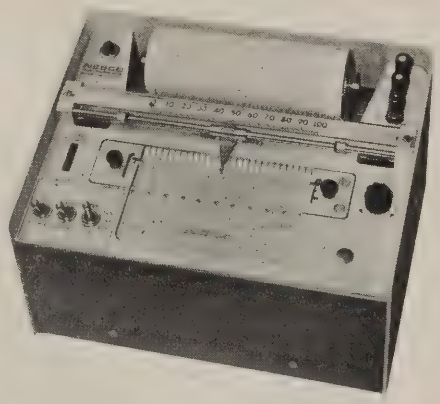
Electro Scientific Industries: Model 292, provides for precise measurements of resistance, conductance, and indurance. Conservative accuracy rating of ± 0.05% for R and G, ± 0.1% for L and C. Five figure measurements can be made using the unique Dekadial decade dials: R, 0 – 1.2mΩ : G, 0 – 1200 MHO : L, 0 – 1200 Hy : C, 0 – 1200 μf





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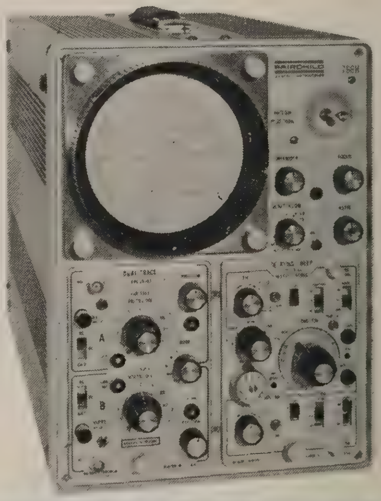
Fairchild 766H Transistorised Oscilloscope

Transistorised lightweight as shown, features:

Dual trace Vertical amplifiers DC to 25 mhz. Sensitivity 0.005 to 10 V/cm. Sweep Unit, 50ns to 2 Sec/cm with delaying facilities. Bright 10x. Presentation of 13 kv. Fast becoming the world's most sought after oscilloscope.



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  Moseley Division
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  Sanborn (Instrument Division)
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The construction of these lamps is such that greater resistance to shock and vibration is obtained plus substantial increase in lamp life.

The Chicago Miniature Flat-End Lamps are available in two types of slide base, miniature bayonet bases and cartridge type bases permitting a variation in mounting arrangements.

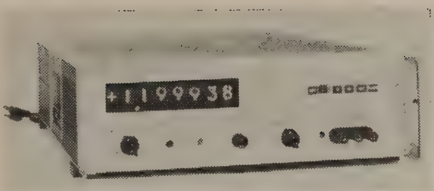
ENQUIRY 407

* * *

NEW 7-DIGIT DIGITAL VOLTMETER HAS 1 PART PER MILLION RESOLUTION

Adding an additional digit permits improving tight specifications and results in a new version of the Hewlett-Packard Model 3460A Integrating-Potentiometric Digital Voltmeter. The new instrument has ten times more resolution; for example, 1 μv can be resolved when measuring the output voltage of standard cells. For the first time, 100 millivolts (1/10 full scale on the 1 vdc range) may be measured with an accuracy of .005% of reading, (± 5 μ volts). The 7-digit DVM is designated Model HO4-3460A. The instrument retains its full specified absolute accuracy (± 0.005% of reading **or** ± 0.0005% of full scale whichever is greater) in normal laboratory environments for a period of at least 90 days.

H04-3460A is designed for fully automatic operation in digital data acquisition systems. Voltage ranges can be selected by external circuit closures to ground. All remote control lines and electrical outputs, including the binary-coded decimal output, are referred to chassis ground and do not interfere with the input guard. Guarding plus integration reduces the effect of common-mode noise by 160 db at **all** frequencies. With its lengthened integrating time (1 sec.), the H04-3460A has excellent superimposed noise rejection characteristics.



Four ranges to ± 1000 volts, with 20% overrange capability on all four, are selectable by pushbutton or by remote control; automatic ranging can be selected by pushbutton on front panel or by closure to ground remotely. Input resistance is constant at 10 megohms ± .03% under all operating conditions.

ENQUIRY 401

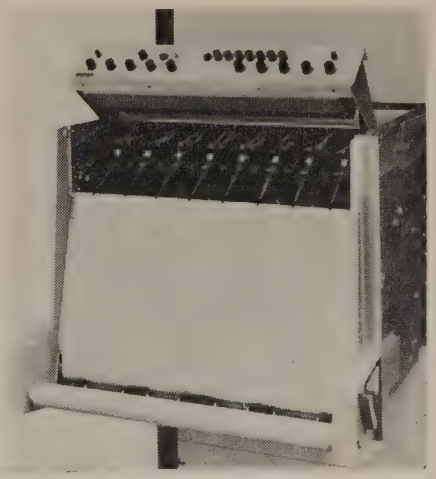
* * *

R-2000 DYNOGRAPH RECORDER

The R-2000 Dynograph Recorder, an all new analogue recording system that delivers highly accurate thermal rectilinear write-out of input data, is now available from the Electronic Instruments Division of Beckman Instruments, Inc.

The self-contained, multi-channel system offers the highest frequency response currently available (85 Hz full scale, 40 mm), with a rise time of less than 3.5 milliseconds.

All silicon solid-state design provides a wide operating temperature range. The direct-writing oscillograph features new high-torque writer units, with new heat stylus and positive stylus locking cradle, that provide unusually high contrast and continuous uniform tracings.



The basic R-2000 is a complete recording system, including amplifiers, power supply, writer units, and chart drive. The compact unit requires only 15¾ inches of vertical panel space, and is mountable in any standard 19-inch rack enclosure.

The basic system is suitable for such applications as telemetry and analogue computer read-out. Accessory amplifiers and input couplers allow accommodation of input signal conditioning for virtually all analogue recording requirements.

ENQUIRY 387

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ENQUIRY 422. USE FORM AT REAR.

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ENQUIRY 349. USE FORM AT REAR.

NEW ELECTROMETER MEASURES CURRENT IN MICRO-MICROAMPERES

The Gyra Model E-307 Electrometer is an exact size replacement for hundreds of obsolete electrometers in existing gas chromatographs. It is the means by which improved performance can be obtained from existing chromatographs. The Model E-307 provides a stabilized "zero" adjustment, greatly improved stability and sufficient output to drive most recorders.

A newly designed input circuit protects the Electrometer from transient detector currents that might change the instrument's calibration.

The Model E-307 Electrometer measures current in micro-microamperes. It is essentially a linear amplifier that takes the voltage drop across an accurately calibrated resistor, amplifies it and delivers an output voltage that is exactly proportional to the input current. To obtain this degree of precision, the utmost stability is required. Line voltage variations, temperature variations and drift in component characteristics are compensated. For maximum sensitivity, it is necessary to balance out current conduction through the carrier gas of the chromatograph. This provision is made in the Model E-307 for detector currents as great as 10^{-7} amps. Polarity is reversible without changing input connections. Substantially improved performance results from the replacement of earlier designed electrometers by the Model E-307 in gas chromatographs. This improved performance permits more accurate analysis of many samples.

ENQUIRY 405

THE KIKUSUI MODEL 536

Is a portable oscilloscope utilizing a 76mm flat-faced cathode-ray tube. Features includes engineering and constructional innovation as well as small size and light weight. Mechanical design uses printed circuit board making it possible to be a compact instrument that has uniform characteristics and is not difficult for service.

Specifications

Vertical Axis:	
Deflection Sensitivity:	100mV p—p/cm at 1 Kc.
Frequency Response:	DC to 1.5 Mc or AC 2c/s to 1.5 Mc, within —3dB.
Input Impedance:	1 Megohm shunted by 30 pF.
Horizontal Axis:	
Deflection Sensitivity:	500mV p—p/cm at 1 Kc.
Frequency Response:	1.5c/s to 400Kc, within +1 or —3dB.
Input Impedance:	1 Megohm shunted by 20 pF.
Sweep Frequency:	Continuously variable 10c/s to 100Kc, and TV. H(15.75/2).
Synchronization:	Internal(+). Internal(—). Line and External .
Cathode Ray Tube:	3KPI—F.
Power Requirements:	AC 100V, 50/60c/s, 50VA approximately. The other voltages can be specified by your optional choice.
Dimensions:	140 wide, 210 high, 355 deep mm.
Weight:	7.4Kg.

ENQUIRY 391

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NEW D.V.M. TECHNIQUE

A substantial increase in demand for Solartron digital instruments is anticipated following the introduction of the LM 1450, — already acclaimed as the world's first low cost professional Digital Voltmeter. An advanced performance specification together with extreme simplicity of operation are combined in a small robust instrument.

A novel 'charge transfer' technique is employed together with advanced low level solid state circuitry to achieve high sensitivity, fast conversion rate, and complete freedom from zero and calibration drift. This is thought to be the first high sensitivity digital voltmeter without front panel zero adjustment presets.

A four digit display employs cold cathode number tubes, and polarity, which is sensed automatically, is also displayed. Accuracy is ± 0.05% of reading ± 0.05% of range. Sensitivity is

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from 20mV full scale, — providing a resolution of 10 Micro Volts, — to 1,000 Volts full scale. The instrument is protected from overloads up to 100 Volts on the three most sensitive ranges where the input resistance is quoted as greater than 100 megohms.

On the attenuated ranges up to 1,000V may be applied without damage and the input resistance is 10 megohms.

There are three modes of operation: Auto, Slow, and Manual. The voltmeter normally runs at 50 conversions per second but the Slow mode allows inputs to be sampled at approximately 1 reading per second without the use of auxiliary equipment. Command readings may be initiated by the manual push button, by contact closure or command pulses. Negative and positive inputs may be digitised under the commanded mode at speeds up to 20 readings per second.

The Voltmeter is able to provide rapid accurate readings on low level signals even in the presence of severe interference. The three terminal guarded input gives virtually complete immunity to any common mode interference. The input isolation is maintained under all operating conditions. The effect of series mode signals may be reduced by the switchable 60dB filter.

Optional BCD or Decimal Fan-Out boards plug into the rear of the Voltmeter to provide suitable output signals to drive printers, punchers, etc. The LM 1450 measures 16.5 cm high x 22.2 cm wide x 42 cm deep and weighs 8.2 kilogrammes.

The Solartron Electronic Group Ltd is represented in New Zealand by E. C. Gough Ltd.

ENQUIRY 384

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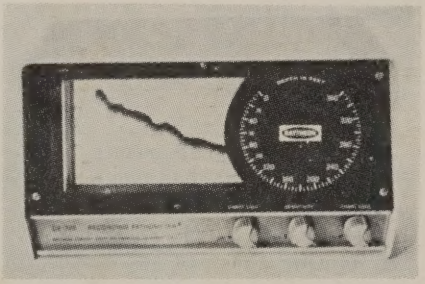
FATHOMETER DEPTH SOUNDERS

The DE-725 Recorder/Indicator is a new, low cost recording Fathometer and dial-reading depth sounder in one compact unit. Although designed for both elements to operate at the same time, this unit's unique papersaver feature will, at the turn of a knob, stop the recorder, yet leave the flashing indicator giving direct readings. The recorder chart is scaled to 240 feet . . . the indicator dial to 360 feet.



This simplified, dependable mechanism traces a permanent record of the precise depth and contour of the bottom on easy-to-read, calibrated paper for later reference in navigation or fishing. The relative strength or weakness of the trace gives excellent indication of a hard or soft bottom. Large individual fish, or schools of smaller fish appear as "clouds" between zero trace and the bottom contour.

SPECIFICATIONS

Depth Range on chart	0-240 ft.
Depth Range on indicator	0-360 ft.
Sounding rate	300 per minute
Voltage input	12 volts DC
Current input	0.12 amps
Accuracy	±5%
Operating Frequency	200 kc

ENQUIRY 395

* * *

RELAYS

A range of relays manufactured in the U.S. is now available from P. H. Rothschild and Co. Ltd. It includes miniature industrial relays designed for industrial application requiring 1 to 8 form C where space, weight and cost are important. Single and bifurcated contacts rated at 3 and 5 amps are available. The use of armco magnetic ingot iron and a onepiece frame and core provide for unusually precise adjustments. Mechanical life expectancy is in excess of 100 million operations. A plastic cover protects the relay and sockets are available.

Other relays in the range include: telephone, power, general purpose, antenna coaxial, time delay high voltage and micro-miniature. Solid frame solenoids using high grade steel in all parts of the magnetic circuit are also available.

ENQUIRY 404

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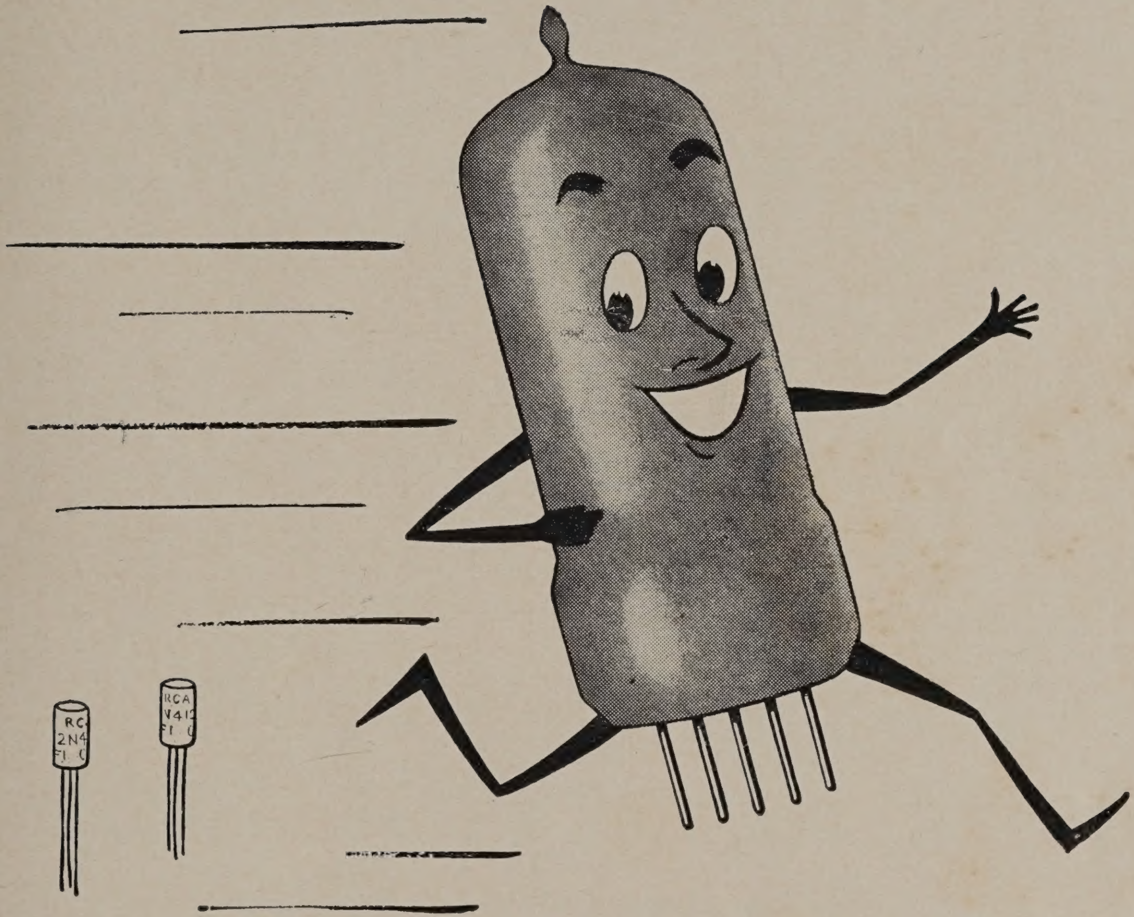

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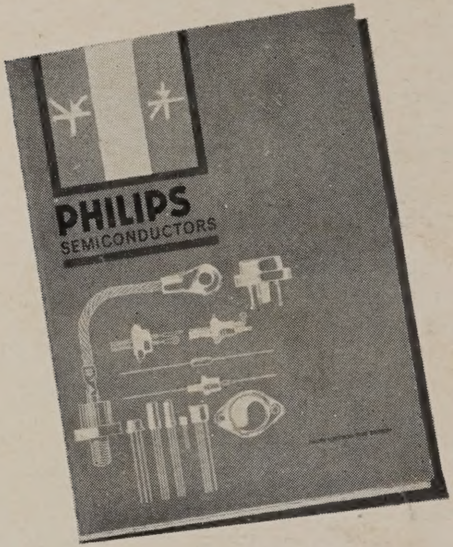

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